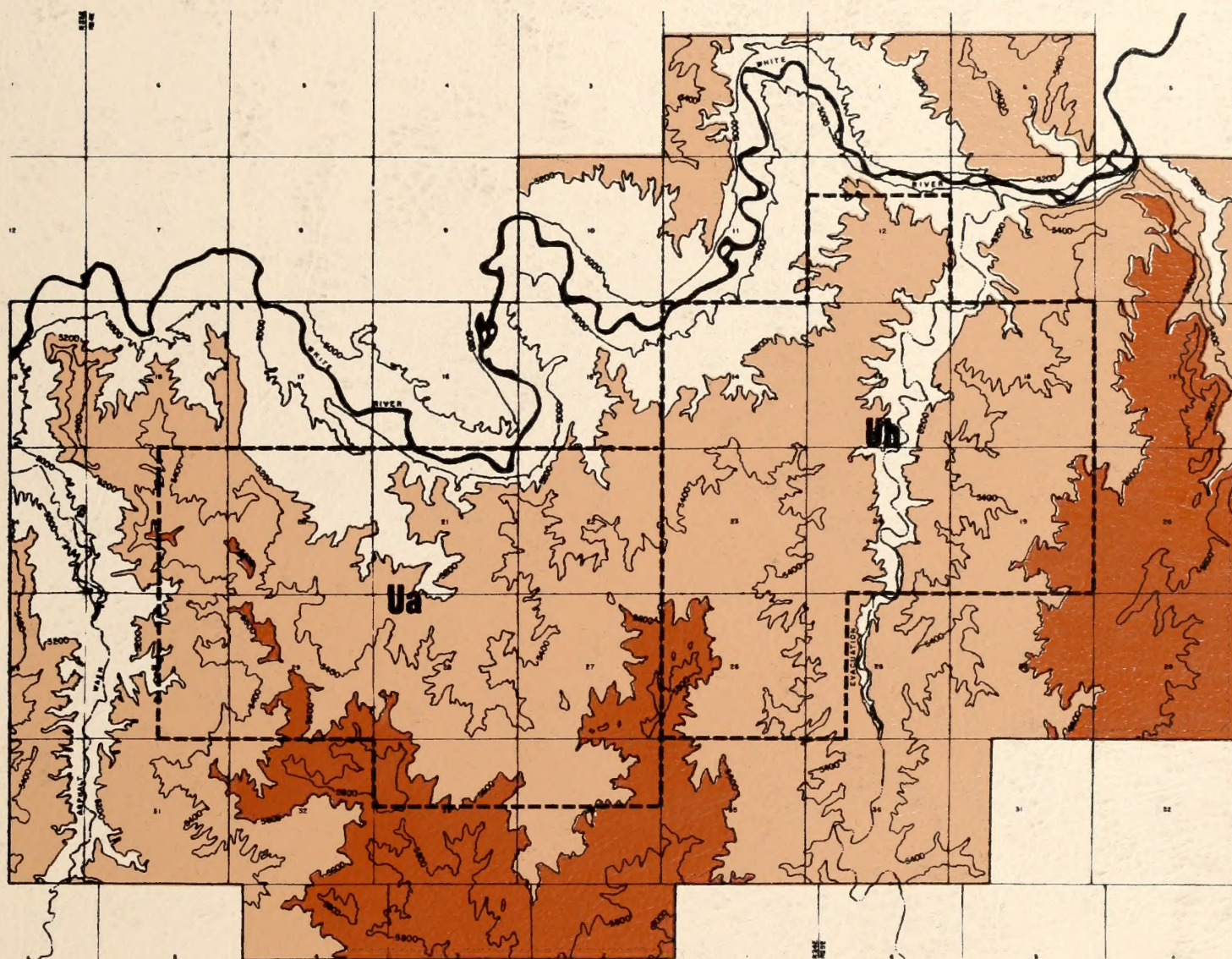




FINAL ENVIRONMENTAL BASELINE REPORT



FEDERAL PROTOTYPE OIL SHALE LEASING PROGRAM TRACTS U-a and U-b UTAH WHITE RIVER SHALE PROJECT

**FINAL
ENVIRONMENTAL BASELINE REPORT**

**FEDERAL PROTOTYPE OIL SHALE
LEASING PROGRAM**

**TRACTS U-a and U-b
UTAH**

WHITE RIVER SHALE PROJECT

VTN Colorado, Inc.

October 1977

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I

INTRODUCTION

And

SUMMARY

I. INTRODUCTION AND SUMMARY

A. INTRODUCTION

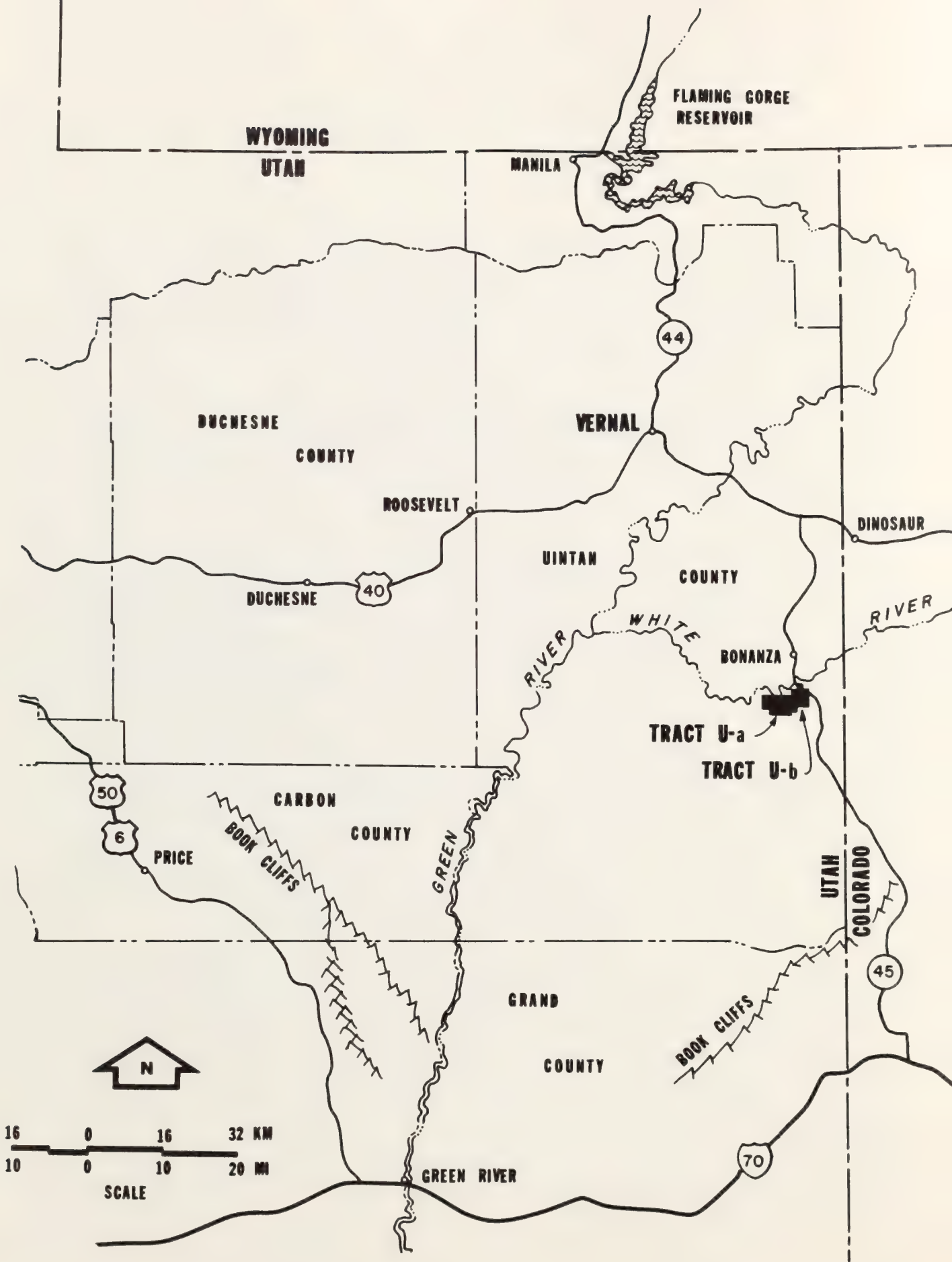
The purpose of this Final Environmental Baseline Report is to present the results of two years of environmental baseline monitoring and data collection on Federal Prototype Oil Shale Lease Tracts U-a and U-b. This work was conducted in accordance with the terms of Oil Shale Leases U-25918 (Ua) U-26194 (Ub) as issued June 1, 1974, by the Department of Interior.

Lease U-25918 (Ua) is held by Sunoco Energy Development Company and Phillips Petroleum Company, and Lease U-26194 (Ub) is held by Sohio Petroleum Company. Both tracts are in Uintah County, Utah, about 50 miles southeast of Vernal, Utah. The tracts are each 5120 acres and are contiguous with one another (see Figure I-1).

The White River Shale Project (WRSP) was formed by the three lease holders in 1974 to prepare and implement plans for the joint development of Tracts U-a and U-b. At that time the WRSP initiated environmental, engineering, and socioeconomic studies. To date the WRSP has published nine quarterly environmental baseline reports, the First Year Environmental Baseline Report, the Detailed Development Plan, socioeconomic baseline and impact reports, and the Final Environmental Baseline Report.

The purpose of the two-year environmental baseline monitoring and data collection program was to compile data to determine the conditions existing prior to any development operations under the leases. The work performed was based on the general stipulations of the oil shale leases and the detailed statements of work established in the Partial Exploration Plan, Environmental Baseline Data Collection and Monitoring Element submitted by the WRSP July 1, 1974, as amended, and on the conditions of plan approval developed by the Area Oil Shale Supervisor.

This report summarizes the findings from the beginning of each baseline monitoring program element to completion of 24 consecutive months of monitoring. All the monitoring periods were within October 1974 through January 1977. This report emphasizes the results of the last half of the monitoring program, although data are presented from both years, and conclusions are drawn from the findings of the entire program. The work from the first half of the program was reported extensively in the First Year Environmental Baseline Report. It is intended, therefore, that this report and the First Year Environmental Baseline Report be used together in reviewing the work accomplished during the two-year environmental program.



vti

PROJECT LOCATION MAP
TRACTS U-a & U-b

FIGURE I-1

The elements of the baseline study are water resources, air resources, biological resources, soils and geology, cultural and paleontological resources, aesthetics, and revegetation of disturbed areas. This report includes the objectives of each element. It also discusses the methodologies used, the results of each program element, interpretation and conclusions of significant findings encountered during the course of the study, and the parameters or species that were found to be indicators of variations between seasons or years and that could be monitored to assess development-related effects on the environment. Each section contains a glossary of terms, references, and in some cases, appendices.

This report was prepared for the White River Shale Project by VTN Colorado Inc. and their subcontractors, as listed below-

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- (b) Utah State University
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- (f) Brigham Young University, Paleontology
 - Dr. Wade Miller
- (g) Fugro Inc., Geology
- (h) Richter and Associates, Seismicity

B. SUMMARY

1. WATER RESOURCES

a. Surface Water

The climate of Tracts U-a and U-b is semi-arid. Annual precipitation ranges from approximately 23 cm (9 in.) in the northwest area of the tracts to about 28 cm (11 in.) in the southeast area, with about 10 cm (4 in.) from May to September, mostly from thunderstorms, and 15 cm (6 in.) from October to April. Approximately 25 days per year have more than 0.03 cm (0.01 in.) of precipitation. Severe local thunderstorms in summer may cause strong gusty winds and local flash flooding. The average annual snow accumulation is about 25 cm (10 in.), but open areas may remain free of snow for most of the winter.

The tracts are in the White River Basin, within the Colorado River system. The streams within this drainage change seasonally in flow and quality. Streamflow is usually low during fall and winter, when there is light precipitation, and reaches peak flow during spring, when snowmelt contributes to the streamflow. Streamflow diminishes as the water from snowmelt gradually drains.

Within the study area there are three basic subdivisions to the surface hydrologic system: the White River, Evacuation Creek, and the washes (Hells Hole Canyon, Southam Canyon, and Asphalt Wash). Each of these systems has followed the overall trend but each has distinct characteristics that make it unique. The White River has three identifiable periods: a baseflow period (approximately August through February) in which the average of 10 m³/s (380 cfs) flow is sustained by ground water seepage mainly from above Meeker, Colorado; a lower basin runoff period (late February through April) in which surface runoff from drainage below Meeker contributes substantial flow (average of 15 m³/s [530 cfs]); and an upper basin runoff period (May through July) in which snowmelt from the mountains above Meeker produces the annual maximum flow (average of 41 m³/s [1430 cfs]). Evacuation Creek has two distinct trends--a baseflow period (between August and February) in which flow is sustained by seepage from aquifers, including the bird's nest aquifer, and a high flow period (March through July) in which flow is increased substantially by snowmelt and rainfall runoff. The actual dates of these periods fluctuate from year to year. Flow in the washes is intermittent and usually of very short duration, from either snowmelt or rainfall (between March and November).

The White River showed little change across the study area during all periods. The flow volume is so much greater than that of the tributaries flowing into it in this region that there was no

noticeable effect on flow between stations upstream and stations downstream of the tracts.

Evacuation Creek, on the other hand, showed several variations with time. Flow patterns within Evacuation Creek are complex. Surface runoff contributes substantial amounts of water to the creek. During both years of monitoring, surface runoff was of short duration but very intense, constituting between 60% and 90% of the flow. Peak flows were usually related to rainfall periods. Runoff from snowmelt contributed to flow only during the first part of March. The volume was considerably less than the annual snowfall would indicate because (1) most of the precipitation was returned to the atmosphere through sublimation of snow crystals or evaporation of melted snow, or (2) was lost to the ground as soil moisture or aquifer recharge. Ground water seepage contributed less water than surface runoff (between 10% and 40%) but is a consistent source of flow in Evacuation Creek, with flow measured at both gauges for all but a few days of the year.

During baseflow in Evacuation Creek, streamflow and the dissolved solids content decreased as flow moved downstream in the area where the stream is in contact with the bird's nest aquifer outcrop. This is an unusual phenomenon, since the dissolved solids content of a stream generally increases. A plausible explanation for this is found in a change in the water chemistry, which indicates that water from the bird's nest aquifer is flowing into Evacuation Creek. Since the flow in Evacuation Creek does not increase, it must be losing water to the bird's nest aquifer. The mixing of water from the two sources causes chemical reactions which precipitate matter and thus decrease the dissolved solids concentration.

The washes--Hells Hole Canyon, Southam Canyon and Asphalt Wash--are ephemeral and tributary to the White River. All three flow irregularly and briefly. Southam Canyon is the most relevant to the study, since about 12 km² (6 sq mi) of its 23 km² (9 sq mi) of drainage area is within Tract U-a. Hells Hole Canyon drains about 70 km² (26 sq mi), none of which is within either tract; and Asphalt Wash drains about 264 km² (100 sq mi), about 2.5 km² (1 sq mi) of which is within Tract U-a.

Flow from the washes varied between the two years of monitoring. The total flow from Asphalt Wash was 22 ha-m (17 acre-ft) in 1975 and 35.7 ha-m (27 acre-ft) in 1976, representing a 23% increase over the previous year. Total flows from Hells Hole and Southam canyons, on the other hand, decreased dramatically in 1976. In Hells Hole Canyon flow decreased 97%, from 370 ha-m (280 acre-ft) in 1975 to 12.2 ha-m (9.1 acre-ft) in 1976; in Southam Canyon flow decreased 76%, from 28 ha-m (21 acre-ft) in 1975 to 6.7 ha-m (5.1 acre-ft) in 1976.

Other aspects of the washes were equally as variable as stream-

flow. Although there was less precipitation in 1976, individual storms were more intense, which should have brought more runoff; instead, there was actually less runoff than in 1975. These inconsistencies emphasize the difficulty of predicting the behavior of desert washes.

Water quality, like streamflow, has seasonal cycles, which are closely related to streamflow patterns. During the baseflow period, the level of dissolved solids is usually highest, since most of the flow comes from ground water seepage, where the water's long contact time with minerals has promoted chemical reactions leading to increased dissolved matter. Suspended sediment levels are usually lowest at this time because surface runoff is too low to generate suspended sediment by erosion.

During highflow, suspended sediment reaches its highest levels because the flow is from surface runoff from snowmelt or rainfall, which cause erosion. Dissolved solids are lowest because of the dilution of ground water seepage by the less mineralized surface runoff. Generally, then, dissolved solids decrease with increasing streamflow and suspended sediment increases with increasing streamflow.

Specific dissolved solids constituents may or may not follow the general pattern. The major dissolved ions--calcium, magnesium, sodium, potassium, sulfate, bicarbonate, chloride and others--usually form more than 90% of all the dissolved solids and follow the general trends to varying degrees. Some of the biochemical constituents and nutrients follow the general trends, but they also follow the biological growth cycle as it varies with water temperature and solar radiation. Trace elements may show no seasonal cycle at all, since their levels are so close to the lower limits of the test process that seasonal variations are less than the test methods can measure or are hidden by levels that fluctuate dramatically in ways that do not follow any general trends.

During the baseline study dissolved solids in the White River were usually 400 mg/l to 600 mg/l during baseflow, 500 mg/l to 700 mg/l during lower basin runoff, and 200 mg/l to 400 mg/l during highflow. Of the major ions, sodium and sulfate varied the most, probably because of the effects of inflow from the lower basin streams. No unusual concentrations of any of the constituents were found, and the quality was such that the water could be used for most purposes.

In Evacuation Creek, dissolved solids were usually between 3600 mg/l and 5000 mg/l except for brief periods associated with rainfall or runoff, when they would drop as low as 1200 mg/l. Sodium and sulfate were the dominant major ions. In terms of quality, Evacuation Creek is not suitable as a domestic water supply and should be used with caution for agricultural purposes. Also, the quality of Evacuation Creek within the tracts is

affected by the interaction between the creek and the bird's nest aquifer. The water entering the aquifer from the creek causes the aquifer to become a more oxidized system, while seepage from the aquifer into the stream causes the stream to be a more reduced system.

Since the washes flow so infrequently, few water quality samples could be collected from them. Generally, dissolved solids concentrations were between 300 mg/l and 3000 mg/l but there were variations from one event to another and even during an event. From the few samples taken it appears that the water is suitable for most uses at most times; however, the quality is variable, and therefore the water should be used with caution.

b. Ground Water

Ground water beneath Tracts U-a and U-b is limited to a fractured zone laced with solution cavities, called the bird's nest aquifer. The aquifer lies near the top of the Green River Formation, about 131 m (430 ft) above the Mahogany Marker. Exploratory drilling to 137 m (450 ft) below the marker disclosed no additional ground water zones. The alluvial deposits along Evacuation Creek, Asphalt Wash, and the Green River contain limited quantities of ground water.

Recharge to the bird's nest aquifer in the vicinity of the tracts occurs principally along outcrops in Evacuation Creek in and above the southern part of Tract U-b. Discharge from the aquifer occurs at the north edge of Tract U-b back to Evacuation Creek and into the White River just north of Tract U-b.

Ground water in the bird's nest aquifer moves northwest across Tract U-b with an average gradient of 83.3 m/km (175 ft/mi). The gradient across Tract U-a is essentially flat. The gradients are reflective of aquifer transmissivity, which on Tract U-b was measured at one location to be about 0.2 l/sec/m (1500 gpd/ft), and at one location on Tract U-a to be about 10.8 l/sec/m (75,000 gpd/ft).

An estimated $98.40 \times 10^6 \text{ m}^3$ (80,000 acre-ft) of ground water are stored within the bird's nest aquifer below Tracts U-a and U-b. Its quality is generally not suited for agricultural, domestic, or commercial use. The water contains an average of 3298 mg/l TDS under most of Tract U-b and 2540 mg/l TDS under most of Tract U-a. The water is mostly a sodium-bicarbonate-sulfate type. No wells are known to produce water exclusively from the bird's nest for any use within the vicinity of the tracts.

2. AIR RESOURCES

The weather on the tracts is essentially determined by their latitude, elevation above sea level, and location with respect to the average storm tracks over the intermountain region. A large portion of the moisture from Pacific storms falls across the Sierra Nevada or Cascade mountain ranges before reaching Utah, and therefore the prevailing westerly air currents reaching the tracts are comparatively dry. Clear skies prevail most of the year, with strong insolation during the day and rapid nocturnal cooling, resulting in fairly wide daily ranges in temperatures. On clear nights the colder air usually accumulates by drainage from higher terrain down to the White River channel and low-lying areas.

Based on the synoptic meteorological patterns observed during the two years of monitoring, high-pressure areas are most prevalent in winter and least prevalent in summer. These high-pressure areas tended to settle over the intermountain region and would often persist for a week or more. Wind speeds during such conditions were usually light to moderate.

The summers are hot and dry. The average mean temperature in July is 27°C (81°F), with an extreme of 41°C (106°F). The winters are relatively cold and dry. The average mean for January and February is -8°C (18°F), and the extreme minimum recorded was -29°C (-20°F) in January 1976. The frost-free period is approximately 110 days.

Surface meteorological conditions remained relatively constant during the two years of monitoring. During the early morning hours, air flowed generally along drainage channels toward low terrain and along the White River. In the afternoon, winds were stronger and less variable, flowing generally from the west or southwest.

On a typical day, diurnal wind speed, temperature, and relative humidity varied consistently. Winds and temperature were lowest in the early morning hours and highest in the afternoon. Relative humidity was just the opposite -- highest in the early morning hours and lowest in the afternoon. Exceptionally high winds were associated with passing fronts and low-pressure disturbances, which occurred most frequently in spring. Low winds were most prevalent in winter, when the weather on the tracts was dominated by persistent high-pressure cells. Surface based or elevated inversions were common in winter.

Upper-air meteorological conditions also remained relatively constant throughout the two years. Particulate concentrations were typical of those of rural areas. Trace metals present in the air were of soil origin. Particulate concentrations varied

from site to site, which was attributed to the location of each site in relationship to unpaved roads and corresponding vehicular traffic.

In general, air quality on the tracts during the baseline study was good, as expected for such a remote area. The only exception was the presence of measurable levels of ozone and non-methane hydrocarbons. During the first year of monitoring both measured ozone and non-methane hydrocarbon levels occasionally exceeded National Ambient Air Quality Standards. During the second year, measured ozone levels approached the standards, while non-methane hydrocarbons continued to exceed the standards.

3. BIOLOGICAL RESOURCES

a. Vegetation

There are four major vegetation types--riparian, sagebrush-greasewood, shadscale, and pinyon-juniper--on the tracts. The riparian type covers a thin strip along the White River. The dominant riparian species are cottonwood trees, salt-cedar, sticky-flower rabbitbrush, greasewood, cheatgrass, willow and salt grass. The riparian type constitutes approximately 2% (about 83 hectares [205 acres]) of the tracts.

The sagebrush-greasewood type occurs on canyon bottoms above the riparian and below the juniper type. The dominant species are greasewood, Russian thistle, big sagebrush, black sagebrush, spiny hop sage, rubber rabbitbrush, sticky-flower rabbitbrush, cheatgrass, borage, horsebrush, needle-and-thread grass, and Indian ricegrass. This type constitutes about 24% (about 1037 ha [2560 ac]) of the tracts.

The shadscale type is found on shallower soils of south- and west-facing slopes and along ridgetops. The dominant species are big sagebrush, shadscale, black sagebrush, galleta grass, horsebrush, blue mustard, cheatgrass, rabbitbrush, sticky-flower rabbitbrush, and greasewood. Shadscale constitutes about 34% (about 1409 ha [3480 ac]) of the tracts.

Pinyon-juniper is found at higher elevations, usually above 1647m (5400 ft). The dominant species are Utah juniper, black sagebrush, greasewood, and rubber rabbitbrush. Juniper constitutes about 40% (1650 ha [4096 ac]) of the tracts.

In general, shrubs of the tracts enter winter dormancy in November. Winter dormancy ends the following March or April, and vegetative growth (stem elongation) begins. Flowers appear from July through September, depending upon the species. Seed dissemination occurs from July through October, depending upon

the species. After seed dissemination, one phenological cycle is complete. Grazing and precipitation affect the timing of these events. For example, insect and sheep grazing on early growth of big sagebrush in April results in vegetative regrowth in July. These phenological events provide a biological base for timing other biological events within the ecosystem.

More than 192 plant species were found on the tracts during the baseline study. Production of annual grasses and forbs was greater in all four vegetation types in 1975 than in 1976. This is attributed to the many low-intensity, evenly-sequenced precipitation events of spring 1975 as opposed to the few intense storms of late spring 1976. Production of annuals was greatest in the riparian type and least in the juniper type for both years.

Perennial plant production, consisting primarily of shrubs in the shadscale and sagebrush-greasewood types and trees in the juniper and riparian types, was a more stable index of productivity than the annuals and forbs. The sagebrush-greasewood, juniper, and shadscale types were from one-half to one-third as productive as the riparian type in new perennial growth each year. Total vegetation production in sagebrush-greasewood, juniper, and shadscale types was one-fifth to one-half that of the riparian type for both years.

A good indication of overall vegetation condition is the percentage of bare ground, which is easily measured. Over a number of years, increased bare ground would indicate an overall deterioration of vegetation conditions, while decreased or stable amounts of bare ground would indicate enhanced or static conditions. Transect or grid vegetation sampling would still be necessary to delineate the condition of individual plant species. For example, increased abundance of cheatgrass would indicate deteriorating conditions, such as from overgrazing, while decreased abundance would indicate improved range conditions.

Vegetation is vitally important in the ecosystem. Vegetation serves as autotrophs, produces oxygen, cycles minerals, builds soil, controls erosion, and provides three-dimensional habitat.

b. Terrestrial Vertebrates

General Sampling

A diverse vertebrate fauna inhabit the tracts because of the variety of habitats available. The vertebrate population is made up of seasonal and permanent residents or transients. Vertebrates are most active during the summer months. Seasonal residents include most of the birds and about two fifths of the mammals; permanent residents include the amphibians, reptiles, some of the birds, and some of the mammals.

The most abundant avian winter residents during the baseline study were gray-crowned rosy finches and dark-eyed juncos, seen in all vegetation types. Abundant avian transients were the song sparrow and white-crowned sparrow, which were restricted to the riparian type. The most abundant avian summer residents for both years were the American kestrel, mourning dove, common nighthawk, Say's phoebe, rock wren, mountain bluebird, and western meadowlark, seen in all vegetation types. The most abundant avian permanent residents were the golden eagle and black-billed magpie in all vegetation types. Marsh hawks were abundant and particular to shadscale. Pinyon jays and plain titmice were abundant and particular to pinyon-juniper. Black-capped chickadees were abundant and particular to the riparian type.

The most abundant mammalian winter residents were sheep. The most abundant mammalian transients were bats. The most abundant mammalian permanent residents were white tail antelope squirrels in shadscale and sagebrush-greasewood; chipmunks in juniper; apache pocket mice in juniper and sagebrush-greasewood; Ord kangaroo rats in sagebrush-greasewood; pinyon mice and desert woodrats in juniper; and deer mice, desert cotton-tails, and mule deer in all vegetation types.

The most abundant lizards were the sagebrush lizard, western whiptail, side-blotched lizard, and eastern fence lizard in all vegetation types. The most abundant snakes were gopher snakes, and whipsnakes in all vegetation types and racers, and wandering garter snakes in the riparian type. Leopard frogs were the most abundant amphibian and were restricted to the riparian type.

A total of 131 avian species (108 of which are seasonal residents), 15 mammalian species, 12 reptilian species, and 4 amphibian species were observed during the baseline study. The most abundant vertebrates were rodents, followed by birds, reptiles, and amphibians.

Faunal indicator species were selected from the vertebrates because their populations are relatively measurable using currently available sampling methods. Vertebrate species displaying high population levels and/or stable population levels during two years of study were pinyon jays, golden eagles, white tail antelope squirrels, Apache pocket mice, Ord kangaroo rats, mule deer, sagebrush lizards, and western whiptails. These species are potential indicators of change (see "Ecological Interrelationships" for indicator species and rationale for selection). Vertebrates are not vital to the functioning of the tracts ecosystem because they do not have a measurable effect on plant or invertebrate production; however, they are an indirect indication of production in species contributing significantly more to the biomass, such as plants, microorganisms, and invertebrates.

Special Studies

Mule Deer: Mule deer use the upland areas of the tracts during winter and move to the riparian area of the White River during spring and summer. Does are particularly restricted to the riparian areas in summer; bucks are not confined to any one area, since they are not limited by the demands of raising fawns.

During the baseline about 150 to 250 mule deer were in the area of the tracts during summer, spring, and fall, and 50 to 100 were in the area during winter. Deer were the most abundant south of the tracts at higher elevations.

At the present time mule deer on the tracts are not good indicators of conditions on the tracts because the herd is unstable, apparently increasing. These deer would be an important indicator species if the herd increased to the large, stable population level observed by the Utah Division of Wildlife Resources prior to the 1969 die-off. Mule deer are not particularly important to the function of the tract ecosystem, but are important as a huntable resource.

Antelope and elk apparently do not use the tracts at all, since neither species was seen there during the two years of monitoring.

Predators: So few predators were observed that distribution by vegetation type could not be determined. Coyotes were observed in all vegetation types. The three bobcats sighted were in washes in sagebrush-greasewood and riparian vegetation. Badgers were seen in shadscale and riparian vegetation. Long-tailed weasels were observed in the pinyon-juniper, sagebrush-greasewood, and riparian types. One mountain lion was observed. All but the badger, which hibernates in winter, were active year-round.

Six predator species were observed during the baseline study. The number of coyote scats found and state-wide scent-post data indicate that coyotes are the most abundant predator in the area. Data from the nearest scent-post did not show consistent population trends, but they did show that the number of coyotes has decreased in the last five years, primarily because of trapping by professional trappers and aerial gunning by the U.S. Fish and Wildlife Service.

Predator populations on the tracts are too small to be good indicators of conditions on the tracts. Other studies have indicated that predators are not vital to the ecosystem of the tracts because there are too few of them to control the large prey populations.

Amphibians and Reptiles: With one exception, amphibian species on the tracts were confined to the vegetation along the White River. In general, they emerged from overwintering burrows in April, concentrated at ponds in May, bred in June, and retreated to burrows in September and October. Tadpoles were active in June and July and metamorphosed to juveniles in August.

Four species of amphibians were observed along the White River; the most common was the leopard frog. From the small number of individuals observed, it appeared that amphibians play a minor role in the ecology of the area.

Lizards occurred in every vegetation type on the tracts. They emerged from overwintering burrows in April and May, bred in May and June, and retreated to burrows in September and October. Juveniles appeared in July and August.

Six species of lizards were observed in four vegetation types. Of these, the northern side-blotched and northern sagebrush lizard were the most commonly observed species. The northern side-blotched lizard was the most widely distributed lizard species, occurring in all vegetation types in both years. In contrast, the short-horned lizard was only seen in one vegetation type, the shadscale. Total lizard abundance by vegetation type and within each vegetation type was not significantly different during the two-year study, indicating that lizards would be good indicators of changing conditions. Lizards are an important segment of the vertebrate population of the tracts in terms of numbers and energy transfer.

Snakes were seen in every vegetation type on the tracts. They emerged from hibernation in April, bred in May, and re-entered hibernation in September and October. Juveniles appeared in September and October.

Six species of snakes were observed in the four vegetation types. Of these the gopher snake was the most commonly observed and widely distributed species. In contrast, the milk snake was seen only once. Total snake abundance by habitat type and within each habitat type was not significantly different for the two years.

Snakes are good indicators of toxic substance accumulations because of their secondary consumer position in energy transfer. However, their relative scarcity precludes any extensive use as indicators of change.

Although not as significant as lizards in terms of numbers of individuals and energy transfer, snakes were numerous relative to many other similar regions of the west. This indicates a generally high faunal productivity of the tracts.

Raptors: Raptors were not confined to any vegetation types, but hunted throughout the tracts. Most of the species present used the area for nesting during spring and summer. Spring and summer nesting residents included the golden eagle, Cooper's hawk, great horned owl, and red-tailed hawk. Spring and summer non-nesting residents included the marsh hawk and turkey vulture. Winter residents included the bald eagle, rough-legged hawk, and goshawk.

In all, approximately 13 species used the tracts on a yearly basis. Kestrels were the most abundant. Of the large raptors, great horned owls were the most abundant followed by red-tailed hawks. In 1975 there were two sightings of peregrine falcons, the rarest raptor seen in the study area.

Raptors would not be a good indicator of conditions on the tracts because of their extreme sensitivity to human intrusion, and it is assumed raptor populations will decline as human activity increases. Raptors do not fulfill a vital role in the functioning of the tracts ecosystem, because rabbits and rodents are so abundant that raptors do very little in controlling their populations.

Waterfowl: Waterfowl on the tracts confined their activities to the riparian areas along the White River between March and September. The 12 species observed during the two-year study were the Canada goose, mallard, gadwall, blue-and-green-winged teal, avocet, willet, Wilson snipe, American merganser, and great blue heron. In addition, in 1975 about 300 sandhill cranes flew south over the area, and some of them landed on the tracts. At about the same time in 1976, sandhill cranes and one whooping crane migrated south over the tracts. Canada geese, however, were by far the most abundant species.

Canada geese would be good indicators of conditions on the White River because of their high abundance and active nesting. The geese are not a significant component of the ecosystem, however, because the area they inhabit constitutes only 2% of the tracts.

Beaver: Bank-dwelling beaver were restricted to the White River riparian areas and were active year-round.

Food cache counts conducted along the White River in 1975 and 1976 totalled 57 and 82, respectively, for a food cache concentration of 2.0 per km. There is no adequate conversion factor with which to estimate beaver population from cache counts; populations are thought to be large, however, since as many as 20 to 30 beaver were seen in the project area in a single day.

Bank beaver would be good indicators of conditions in the White River because the number of food caches did not vary

significantly during the baseline program, indicating that beaver populations there are relatively stable. Beaver are currently an important part of the riparian ecosystem because of the effect they are having on vegetation. By feeding on shrubs and trees in ever-widening circles about their dens, they tend to delay or prevent establishment of mature plant communities, to the benefit of cattle and most wildlife.

Livestock: Cattle are grazed primarily in the riparian areas along the White River from June 1 to late October. Sheep are browsed in all four vegetation types on the tracts from December through April. Approximately 1800 sheep and 160 cattle are on the tracts each year. They have had a marked effect on the ecosystem in reducing available forage for wildlife as a result of a long history of overgrazing.

Cottontail Rabbits: Cottontail rabbits were found in all four vegetation types on the tracts and are active year-round. Populations increased significantly from 1975 to 1976, with almost five times as many rabbits in 1976 as in 1975. This increase has continued despite heavy hunting pressure.

Rabbits would not be a good indicator species because they experience such extreme population fluctuations. They serve an important function for vertebrates, since they are one of the main prey species for avian, mammalian, and reptilian predators.

Mourning Doves: Mourning doves were found in all four vegetation types, but were observed most often in the sagebrush-greasewood and riparian types. They inhabited the tracts from April into September.

The mourning dove coo-call route was not run often enough to determine the exact number of doves on the tracts. During the times the route was traversed, there were about 0.08 doves per hectare. This number coincides with data from the Dead Man's Bench study area, which has the highest dove population density in the state.

Mourning doves would be good indicators of conditions on the tracts only after years of data collection from coo-call routes. Apparently they do not play an important role in the functioning of the tracts ecosystem.

c. Terrestrial Invertebrates

During the baseline study the distribution of terrestrial invertebrates by vegetation types depended on the distance from the White River of the plant swept for insects and by the presence or condition of the bloom. In general, plants sampled near the White River were richer in insects than the same

plant species sampled farther away from the river regardless of vegetation type. This tendency became more pronounced as the summer progressed. The presence of flowers always resulted in greater insect abundance and diversity. Although a few insect species occurred on one host plant or a closely related group of host plants only, most insect species were found on many different plant species.

Approximately 2210 species of insects were identified on the tracts, and there are undoubtedly more. A number of these species had never been identified anywhere before. Relative abundance by vegetation type indicated that insect populations and the number of species diminished with increasing elevation, gradually from riparian to sagebrush-greasewood to shadscale and more drastically from shadscale to juniper.

Terrestrial invertebrates are not good indicators of conditions on the tracts because the number of species and individuals is too great to be sampled adequately (statistically) with currently available methods.

Terrestrial invertebrates, both above-ground and below-ground forms, are extremely important in the ecosystem. Invertebrate herbivores and carnivores probably move more energy and material through the ecosystem per unit time than do vertebrates. Desert invertebrates are responsible for the initial processing of dead material, a vital first step in the cycling of nutrients necessary for plant growth. Invertebrates also fulfill the summer food needs of entire taxa or vertebrates when other food is scarce, and insect pollinators are necessary for reproduction of some plant species.

d. Aquatic Biology

The White River is typical of many other warm-water streams of the Colorado River Basin, such as the Yampa, San Juan, etc. The water is hard in regard to its chemical quality and usually turbid, with suspended sand and silt. Transparency based on a standard test was sometimes less than 2.5 cm, and sheep or deer fecal pellets were found in the debris at nearly every invertebrate sampling location. Discharge varied from approximately 7 m³/sec to 85 m³/sec (250 cfs to 3000 cfs), with flow usually occurring as a result of runoff from snowmelt in late June.

Periphyton growth in the White River is limited to turbidity and by the scouring action of high current velocity and suspended particles. When the water becomes low and clear in autumn, attached algae grow rapidly until limited by reduced temperature and photoperiod.

Phytoplankton is nearly all derived from periphyton that grow near the surface. Measured phytoplankton density was usually less than 100 cells/ml.

During the baseline study macroinvertebrate populations were dominated in summer by mayflies (*Traverella albertana*, *Lachlania saskatchewanensis*, *Heptagenia elegantula*, etc.) and hydropsychid caddis larvae. In winter, stoneflies dominated the macrobenthos, with *Oemopterys fosketti* *Capnia* spp. and *Isogenoides frontalis* the most abundant. Chironomid larvae and tubificid worms were present in silted areas, but rarely in dense populations. Diversity indices were usually between 2.0 and 3.0. Mollusks were not found, and copepods, the only crustaceans found, occurred in only one sample in two years. Leeches were not found in the first year, but several fish captured in August 1976 were infested with *Illinobdella moorei*.

Fish populations, consisting of warm-water species, were scattered and were difficult to sample. Red shiners (*Notropis lutrensis*) and flannelmouth suckers (*Catostomus latipinnis*) were the most common species. Channel catfish were the only common species that could be considered a game fish. Sampling showed no detectable or persistent changes in population structures of the sampled populations as the river crossed the tracts.

Evacuation Creek is ephemeral and is therefore of limited biological importance because most aquatic insect populations cannot become established when the stream occasionally dries up. The stream does not support a fishery, although minnows and young-of-the-year suckers were found on several occasions.

Three groups of invertebrates would be good indicators of conditions in the White River. These are ones that occur in the summer only, the winter only, and year-round. The most abundant species would be the most suitable for monitoring. The summer group could include the mayflies, the winter group could include the stoneflies, and the year-round group could include the mayflies and dragonflies.

e. Microbiology

During the baseline study, microorganisms, aerobic and anaerobic bacteria, streptomycetes, and fungi were most active in spring and fall, when measured respiration levels were highest. Water potential, exchangeable ammonium, nitrogen fixation potential, and ATP concentration all followed the respiration pattern. Other parameters measured during the baseline study did not reveal any consistent two-year trends. In general, numbers and activities decreased with depth except when more moisture was available at depth.

The number of microorganisms did not change significantly through time or from one vegetation type to another. Numbers gradually declined from spring into summer and increased in fall. The order of magnitude of numbers of aerobic bacteria and streptomycetes was the same. The same held true of bacteria and fungi. These latter two groups were about an order of magnitude less abundant than the aerobic bacteria and streptomycetes.

Microorganisms would not be good indicators of tract conditions because of their immense numbers and moisture-dependent variability, factors that preclude statistical treatment of results. Microorganisms are vital in all natural ecosystems, since they play a major role in the cycling of nutrients either by breaking down organic material into chemical elements, which are then available to plants, or by transforming nutrients into a form that is usable by plants. If these processes are slowed or halted, plant growth is reduced or stopped. Perhaps the most critical of the nutrient cycles in deserts are the nitrogen and carbon cycles.

f. Threatened and Endangered Species

No threatened or endangered plants, animals, or fish species were found on the tracts, although several such species have been sighted in the area. Peregrine falcons have been sighted in the study area on several occasions, and a whooping crane flew over the tracts twice during the study. The tracts also contain suitable habitat for several threatened or endangered plants and fish. The plant species are *Erigonum ephedroides*, *Gilia mcvicerae*, and *Astragalus lutosus*. The fish species are the Colorado squawfish (*Ptychocheilus lucius*), humpback chub (*Gilia cypha*), bonytail chub (*Gilia elegans*), and humpback sucker (*Xyrauchen texanus*). The last two are not actually listed as endangered, but they are rare.

4. SOILS AND GEOLOGY

a. Soils

The soils of the tracts are mainly shallow or very shallow on sloping to steep upland terraces cut by numerous intermittent drainages and with many areas of rock outcrop and rock escarpments. Nine different soil types -- A, As, Bs, Ds, E, F, N, and W -- were identified on the tracts. These soils fall into six subgroups -- Lithic Calciorthids, Typic Calciorthids, Lithic Torriorthents, Typic Torriorthents, Typic Natrargrids, and Aquic Ustifluvents.

The A, As, B, Bs, and F soils are those of the shallow areas. They are light-colored, moderately calcareous sandy loams, loams, channery sandy loams, and channery loams. The soils in the drainage areas of Southam Canyon are generally Ds soils which are deep, light-colored, moderately calcareous sandy or channery loams. Along the Evacuation Creek drainage areas the soil is deep and moderately fine textured and is strongly alkaline with a high exchangeable sodium content. The W soils occur adjacent to the White River. They are deep and silty, seasonally wet in the deeper horizons, and generally have a high salt content.

The suitability of each soil for a wide variety of engineering uses depended on the soil type. In terms of this study the most important finding was that D soils would be the most suitable for use as topsoil in reclamation. In all chemical parameters the soils were found to be typical of those of desert areas. No radioactivity above a normal background level was identified.

Infiltration rates varied with the soil type. The upland soils (A, As, B, Bs, F) had rates of about 3.6 cm (1.4 in.) per hour. Bottomland soils (D) had higher rates -- about 6.1 cm (2.4 in.) per hour. The soils formed on the alluvium of the White River (W soils) had much slower rates of uptake -- about 1.5 cm (0.6 in.) per hour. As expected, soils affected by excess sodium (N soils) had the lowest infiltration rates of all the soils tested -- about 0.8 cm (0.3) per hour.

b. Geology

Tracts U-a and U-b lie within the Uinta Basin, a prehistoric depositional lake basin. The land within the tracts is a gently north-sloping plateau with steep-walled canyons containing ephemeral streams subject to flash flooding. Intertributary divides are capped by resistant rock strata, creating mesas, cuestras, and hogbacks. The major canyons and divides within the tracts are north-south trending and oriented perpendicular to the White River, which lies north of the tracts.

The White River is the only perennial stream flowing through the tracts. Evacuation Creek is an intermittent stream, and the remaining watercourses are ephemeral. The drainage pattern on the tracts varies with surface lithology and is influenced by joint patterns.

The bedrock that outcrops in the region includes the Wasatch, Green River, Uinta, and Duchesne River formations. These formations reflect different stages in the development of Lake Uinta and the Uinta Basin.

The strata at the site generally dip less than 5° north or northwest. There are no known faults and only minor folds. One set of primary and three sets of secondary near-vertical joints occur throughout the site area.

The oil shale is contained in the Green River Formation, which is exposed along the south and east margins of the basin and is concealed by younger sediments in the central and northern parts of the basin. Available drilling information indicates that the thickest, richest oil shale is in the eastern half of the basin, mostly concealed by younger rocks of the Uinta Formation.

The tracts lie within the lowest seismic risk zone. Occasional landslides and debris flows have occurred as a result of severe thunderstorm and accompanying flash floods.

5. CULTURAL (HISTORICAL AND PREHISTORICAL) AND PALEONTOLOGICAL RESOURCES

The cultural resources of the study area indicate it has been occupied intermittently from about 5000 years ago through recent times. Except for the historical and some prehistoric sites, cultural periods and affiliations of most of the sites could not be determined. The Ignacio Stage Stop, located off the tracts, was the only historic site identified, because of its association with the historical events of the region and because of its late pioneer architecture.

Fossils were found in most of the project area in both the Green River and Uinta formations of the Eocene Epoch. Fossil finds included leaf impressions, petrified wood, and insect and fish fossils in the Green River Formation; and shells, petrified wood, turtle bones, crocodile bones, and brontothere bones in the Uinta Formation. Thirty-nine sites were identified--18 on and 3 off the tracts.

Paleobotanical and invertebrate fossils are useful as general indicators of past climatic conditions and paleoenvironments. Twenty-one sites located during this investigation were found to be useful as time indicators and in determining past climatic and environmental conditions for a given time and place. The discovery of several types of brontotheres on the tracts is considered significant, especially in view of their abundance and good state of preservation.

6. AESTHETICS

Tracts U-a and U-b are in a semi-arid desert environment characterized by sparse vegetation and stark red, buff, and brown rock formations against the usually clear Utah sky. The major landforms and points of interest surrounding the tracts are the Uinta Mountains, Book Cliffs, Wasatch Plateau, Flaming Gorge National Recreation Area, Dinosaur National Monument, and the Green River. The climate is characterized by dust, daily extremes in temperature, and dryness.

The aesthetic resources were defined in terms of three distinct landscape units: the ridgetop-basin unit, the canyon unit, and the White River unit. The ridgetop-basin unit comprises the ridgetops serving as drainage divides, from which can be seen panoramic views of the surrounding desert landscape. In contrast, the setting on the ridgetops themselves are dominated by unusual micro-landforms such as lichen, ripple marks, precipitation cusps, honeycombed rocks, and seedling pinyon trees, and by unique geological features such as rock pinnacles, water pockets, balanced rocks, and rock windows.

The canyon landscape unit included Evacuation Creek, lower Southam Canyon, Asphalt Wash, and all steep-walled tributaries to these drainages and to the White River. The landscape is characterized by nearly vertical canyon walls and enclosed views enhanced by geological detail, micro-changes in vegetation, and water in ephemeral stream courses.

The White River landscape unit features the White River, the only perennial stream on the tracts. The views are enclosed by steep canyon walls, and along the river are thick vegetation and cottonwood trees, a pleasing contrast to the sparse vegetation and stark geological detail of the surrounding area.

7. REVEGETATION PROGRAM

Revegetation of the processed shale disposal areas with natural vegetation is being conducted by the Agricultural Experiment Station of Utah State University (USU). Greenhouse studies are continuing at USU, in Logan, Utah, and field revegetation studies using processed shale are being conducted north of Tract U-b.

Reseeding of disturbed areas on Tracts U-a and U-b has been completed. Drill sites and access to drill sites were reseeded in fall 1975 using procedures approved by the Area Oil Shale Office (AOSO) and the Bureau of Land Management (BLM).

Following reseeding, the sites were inspected by agency personnel (AOSO and BLM), who determined that the reseeding was well done and that the sites were left in good condition. The conditions for reseeding success were excellent during spring 1975; however, in spring 1976 conditions were poor for the new seedlings as well as for the existing vegetation. Perhaps in only two out of five years will conditions be favorable for any significant regeneration success. The success of the fall 1975 seeding program can be evaluated only by observing at least two growing seasons (spring 1976 and spring 1977) and possibly a third season (spring 1978).



II WATER RESOURCES



II. WATER RESOURCES

The water resources investigation was conducted to establish baseline conditions on the tracts. To characterize surface water a network of 14 gauging stations were established on the major drainages to provide data on stream quantity and quality both upstream and downstream of each tract. The data collected from these stations included continuous streamflow, water temperature, precipitation, specific conductivity, and sediment records; and periodic water quality analysis for selected inorganic and organic chemical constituents.

To characterize ground water a system of 29 drill holes were completed to locate aquifers that may be potentially impacted by mining activities and determine their hydraulic properties. Investigations were made to determine both regional and local ground water movement and ground water level fluctuation, ground water quality, sources of aquifer recharge and discharge, alluvial aquifer quality, seeps and springs locations, and inter-relationships that may exist between the ore zone, surface waters, and aquifers. Emphasis has been placed on reporting the second-years data with referencing back to the First Year Environmental Baseline Report (FYEBR) for comparisons. Figures and tables of 1975 data were utilized when correlations between years were significant.

A. SURFACE WATER RESOURCES

1. PHYSICAL HYDROLOGY

a. Methodology

The methodology for the surface water hydrology program is described in detail in the First Year Environmental Baseline Report (FYEBR). The second year of monitoring essentially followed the same program, except for the Area Oil Shale Supervisors' (AOSS) approved modifications designed to improve the quality and overall efficiency of the hydrologic baseline record. These modifications were approved January 26 and June 24, 1976, as revisions to the original August 27, 1974, Conditions of Approval.

The 14 permanent stream-gaging stations were installed and in operation beginning October 1974 (see Figure II-1). Stations S-7, S-8, and S-15 on Evacuation Creek and its drainage area were discontinued in January 1976 because Southam Canyon was selected as the processed shale disposal area and not the area

within Evacuation Creek originally considered as an alternate site. Monitoring at Stations S-1 and S-4, on the White River was changed from year-round to non-ice periods, typically May through September. Station S-4 on the White River was discontinued because the same data were being collected at three other sites on the White River. Monitoring at the Hells Hole Canyon Station (S-5) was also changed to periods of snowmelt and summer storms (April through September) rather than year round.

b. Summary of Results

General Characteristics

The tracts are in the White River Basin, within the Colorado River system, as seen on Figure II-2. The White River Basin comprises two major physiographic areas: the mountainous uplands (Upper Basin), from which most of the flow from the basin originates, and the semi-arid lowlands (Lower Basin), through which the streams flow. As they pass through the lowlands the streams maintain nearly constant flow but deteriorate in quality from evaporation and side-channel inflow of poor-quality water.

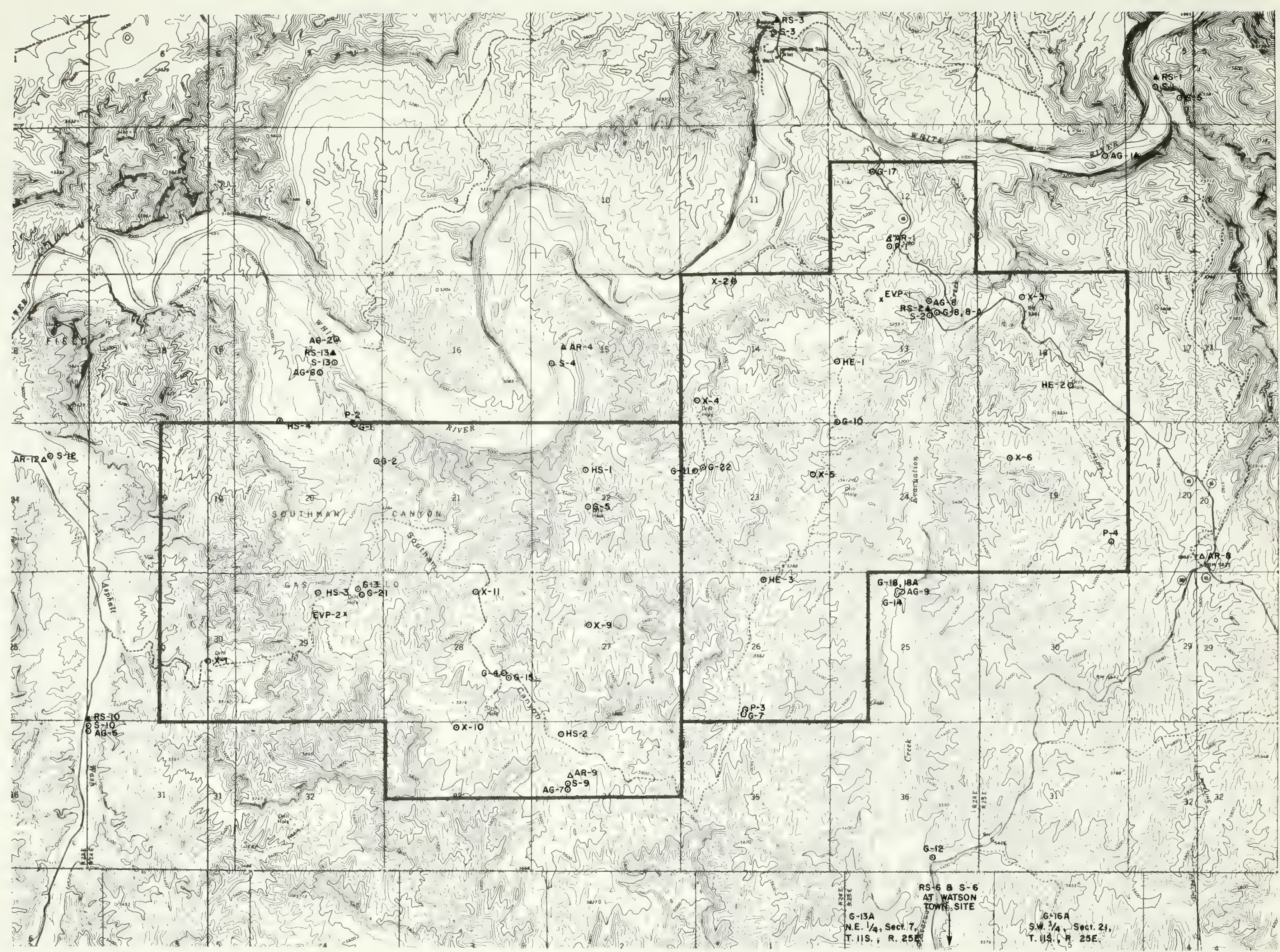
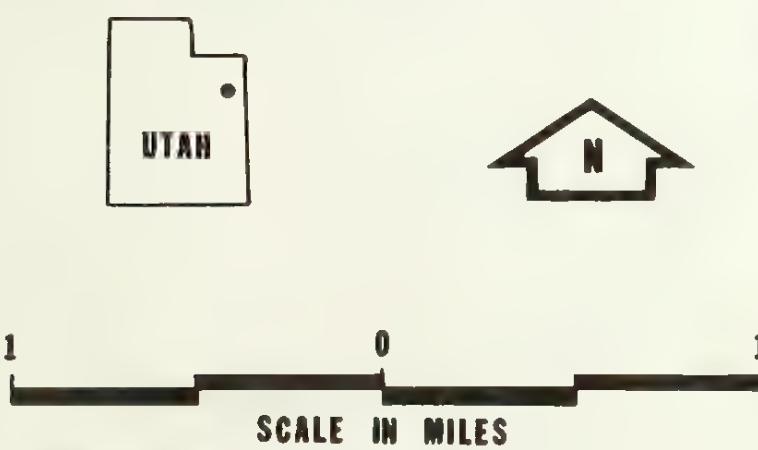
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The White River, the main body of water in the White River drainage and near the tracts, changes seasonally in flow and quality. During fall and winter streamflow is usually low because of light precipitation. Winter snows do not contribute to streamflow until spring snowmelt, when the river reaches peak flow. During summer, streamflow diminishes as the water from snowmelt gradually drains. The water quality is best during spring, when snowmelt is the major portion of streamflow, and deteriorates through the rest of the year as ground water seepage becomes a larger portion of the flow.

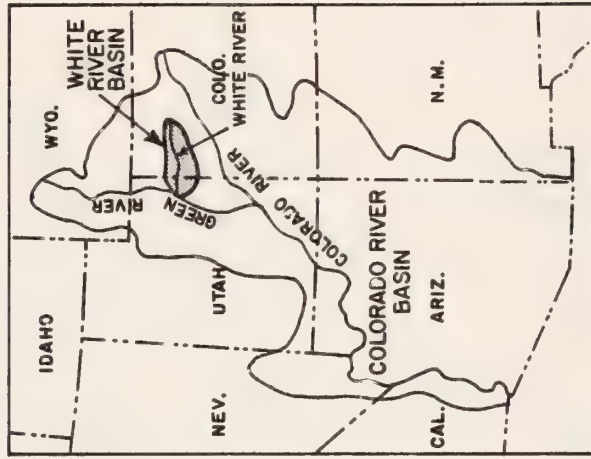
Evacuation Creek is the only other stream on the tracts that sustains flow year round. The other streams are a series of ephemeral washes tributary to the White River (Hells Hole Canyon, Southam Canyon, and Asphalt Wash).

Streamflow and water quality records are available from the U.S. Geological Survey (USGS) gauging stations at several points along the White River; the other streams had not been gauged before the baseline monitoring program.

- LEGEND**
- S SURFACE WATER MONITORING STATION
 - P PILOT TEST HOLE (WATER)
 - G GROUND WATER MONITORING STATION
 - HE EXISTING GEOLOGIC CORE HOLE, EVACUATION
 - HS EXISTING GEOLOGIC CORE HOLE, SOUTHAM
 - X EXPLORATION GEOLOGIC CORE HOLE
 - AG ALLUVIAL WELL (WATER)
 - ▲ AR PRECIPITATION, AUTO (WATER)
 - ▲ RS PRECIPITATION, STORAGE (WATER)
 - × EVP EVAPORATION PAN (WATER)



WATER AND GEOLOGIC RESOURCES BASELINE MONITORING STATIONS



WHITE RIVER BASIN

SCALE 1 : 1,000,000



FIGURE 11-2



Precipitation

There were few attempts to study precipitation or evaporation in the project area previous to the baseline monitoring program. The only previous attempt was a station established near Watson that was discontinued in 1938. The best source of information, and the one used in this study, is a hydrological inventory of the Uinta Basin prepared by Austin and Skogerboe (1970), which characterizes the entire basin based on all relevant historical data. These data show the average annual precipitation for the project area to be about 25.4 cm (10 in.), varying from about 23 cm (9 in.) in the northwest area of the tracts to about 28 cm (11 in.) in the southeast area (refer to the FYEBR for additional information).

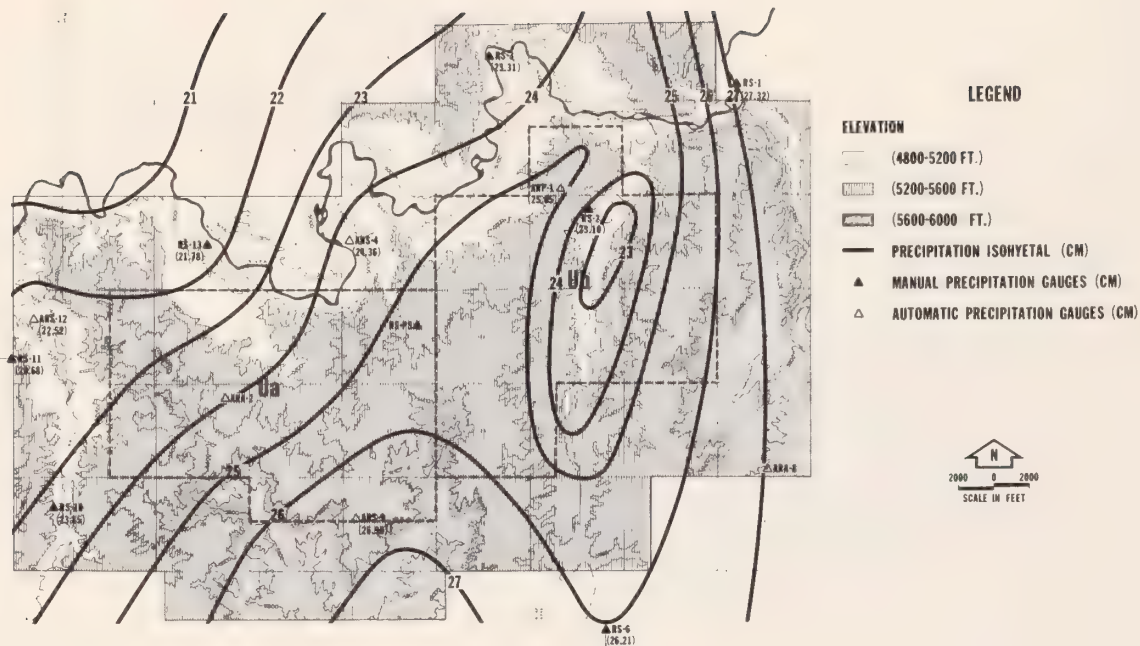
The annual average precipitation during the two years of monitoring is shown on Figure II-3. The average for 1975 and 1976 was 23 cm (9 in.) about average for the region.

First-year data indicated that terrain was the main factor influencing precipitation patterns on the tracts; however, after a second year of data collection it was evident that although terrain is an important factor, individual storms are much more significant than first assumed. Snowfall patterns were similar during both years, with snowfall evenly distributed over the tracts by storms of regional extent. Rainfall patterns, on the other hand, were variable and sporadic, reflecting the combined influences of localized storms and features such as canyons and ridges.

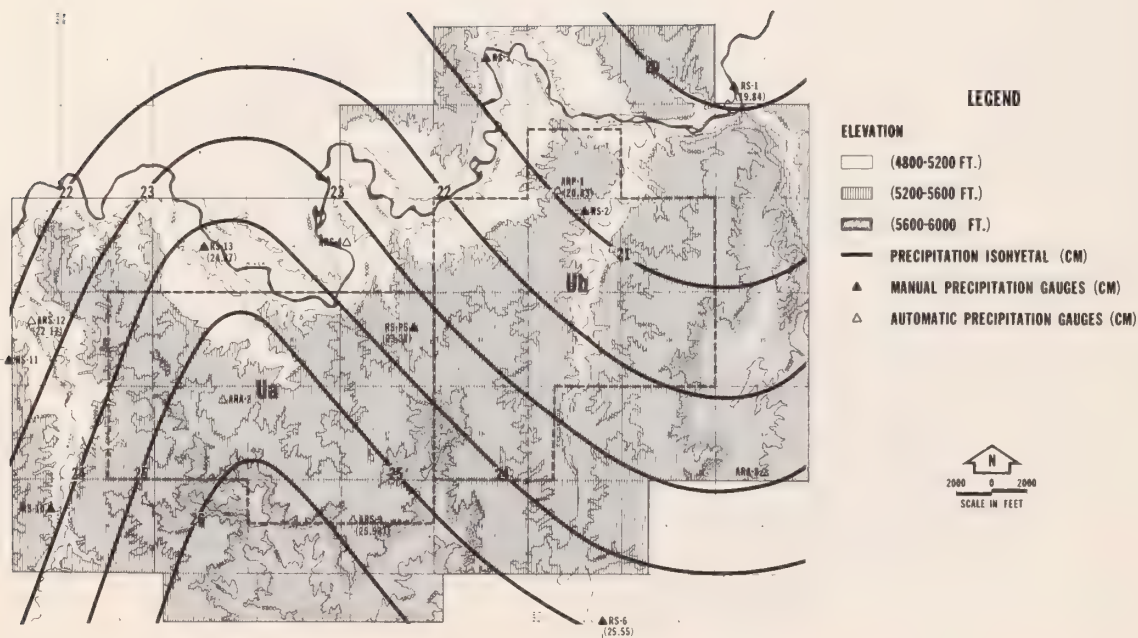
The data from the combined two years of monitoring indicated that rainfall was heavier on the ridge tops and lighter in the valleys. This is a result of orographic stimulation and evaporation in transit during rainfall from greater exposure in the longer fall to lower elevations; however, slow-moving, intense, isolated storms caused heavy amounts of precipitation over small areas of both ridges and valleys.

In the first year, 40 precipitation events were recorded, and in the second year, only about 30 events; thus although there was an average of 6% less precipitation at the gauges in 1976, each storm averaged about 20% more precipitation. Despite the different pattern, during both years precipitation was still heaviest in upper Southam Canyon (high elevation) and lowest in Evacuation Creek drainage (low elevation).

Figures II-4 through II-7, showing quarterly precipitation during 1975 and 1976, more clearly indicate the seasonal distribution of precipitation and the differences between the two years. In both years, spring was definitely the period of maximum precipitation, but as indicated on the maps, rainfall during spring 1976 occurred in a few major storms that had less

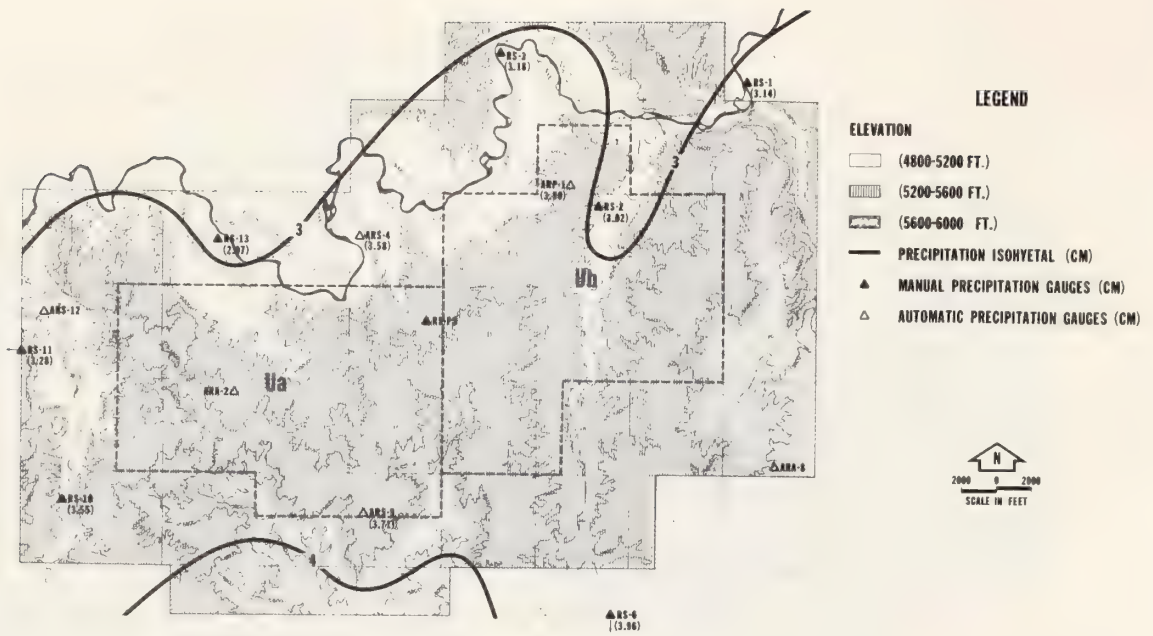


ANNUAL PRECIPITATION
OCTOBER 1974 - SEPTEMBER 1975

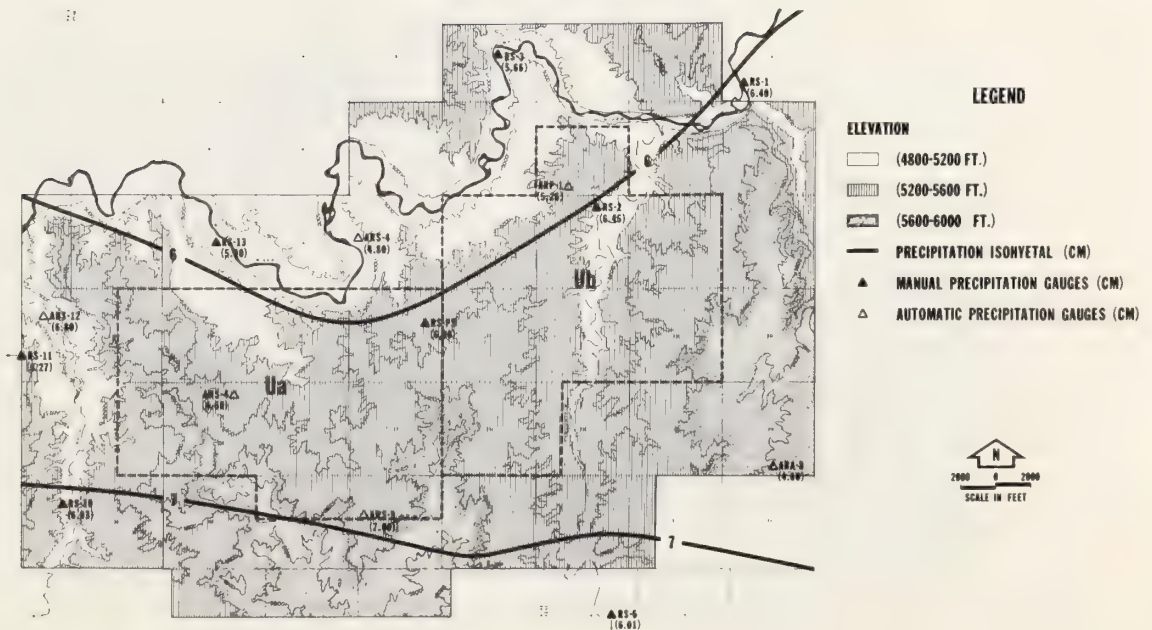


ANNUAL PRECIPITATION
OCTOBER 1975 - SEPTEMBER 1976

FIGURE II-3

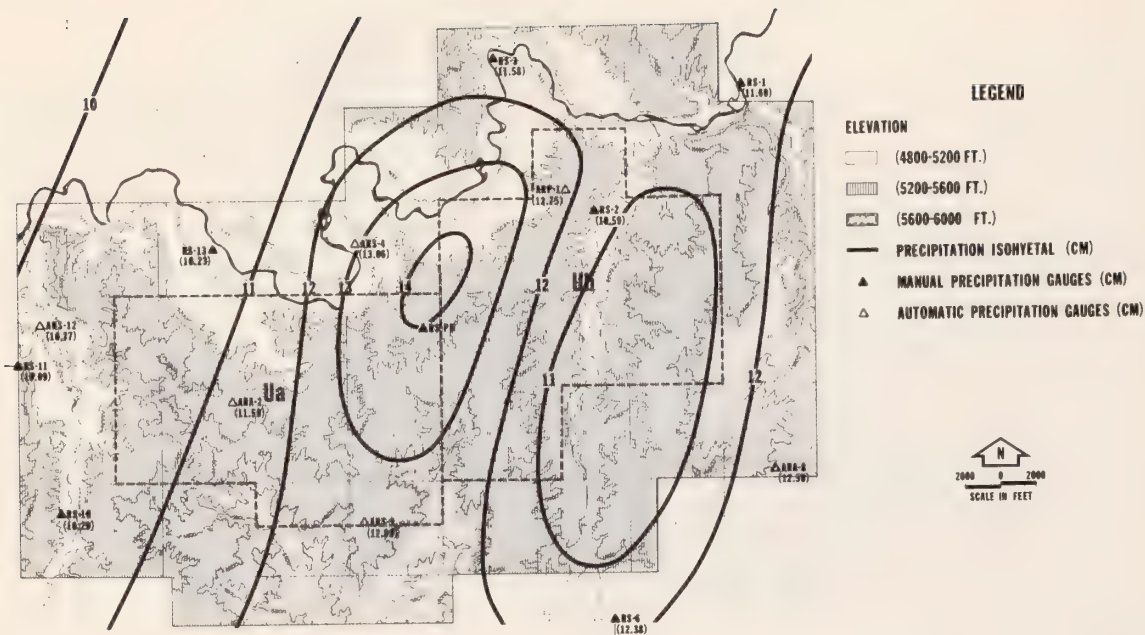


FALL PRECIPITATION OCTOBER - NOVEMBER - DECEMBER - 1974

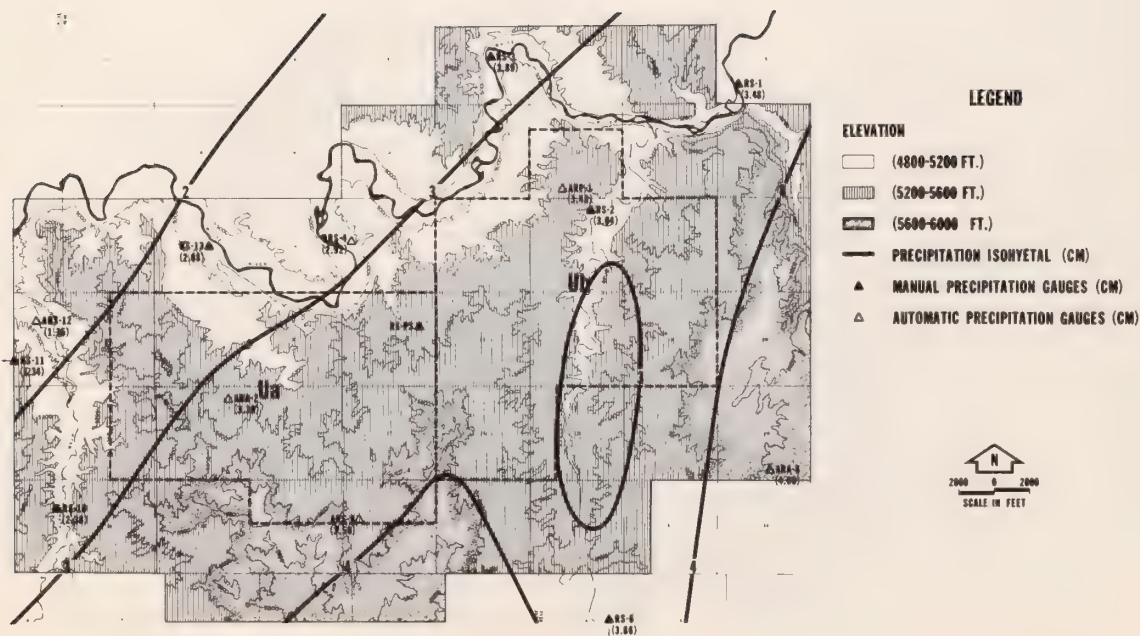


WINTER PRECIPITATION JANUARY - FEBRUARY - MARCH - 1975

FIGURE II-4

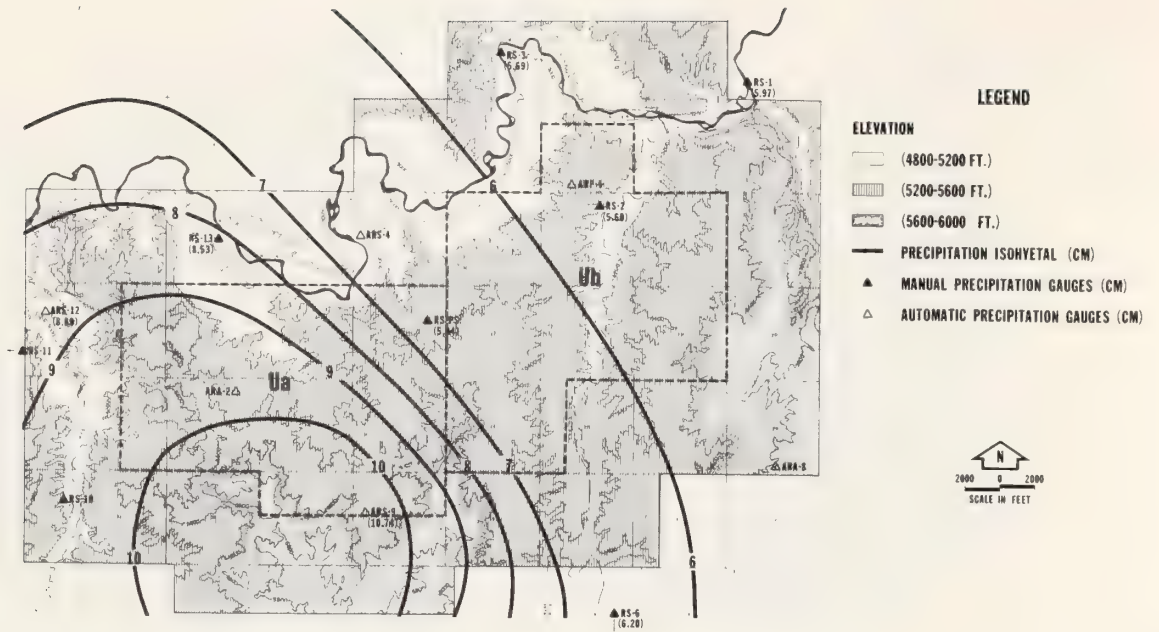


SPRING PRECIPITATION APRIL - MAY - JUNE - 1975

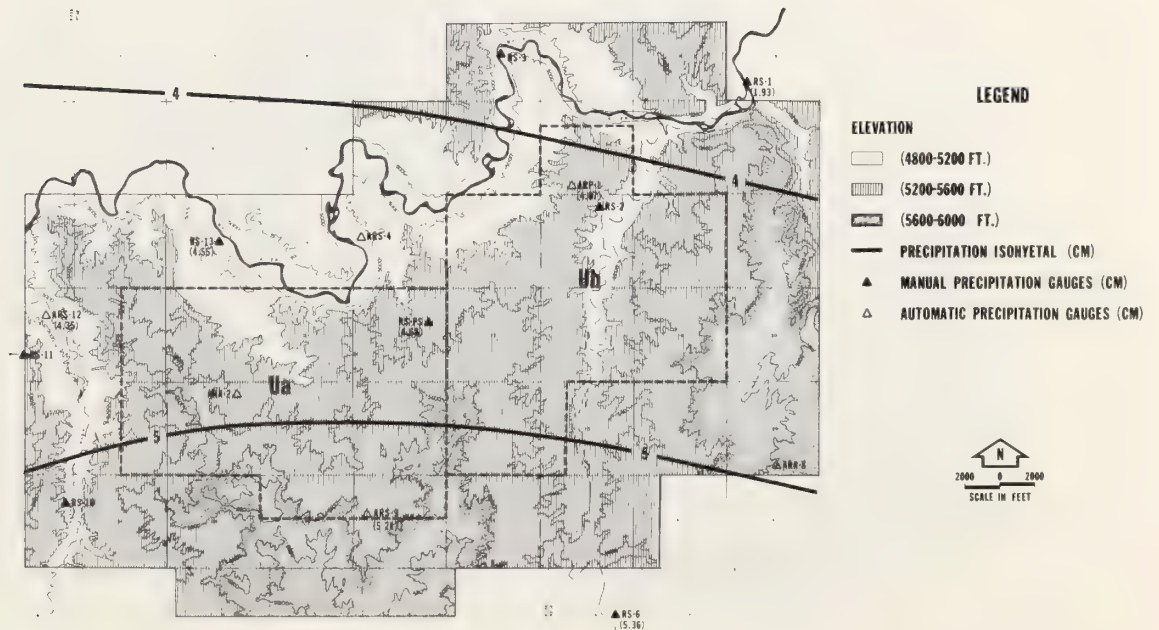


SUMMER PRECIPITATION JULY - AUGUST - SEPTEMBER - 1975

FIGURE II-5

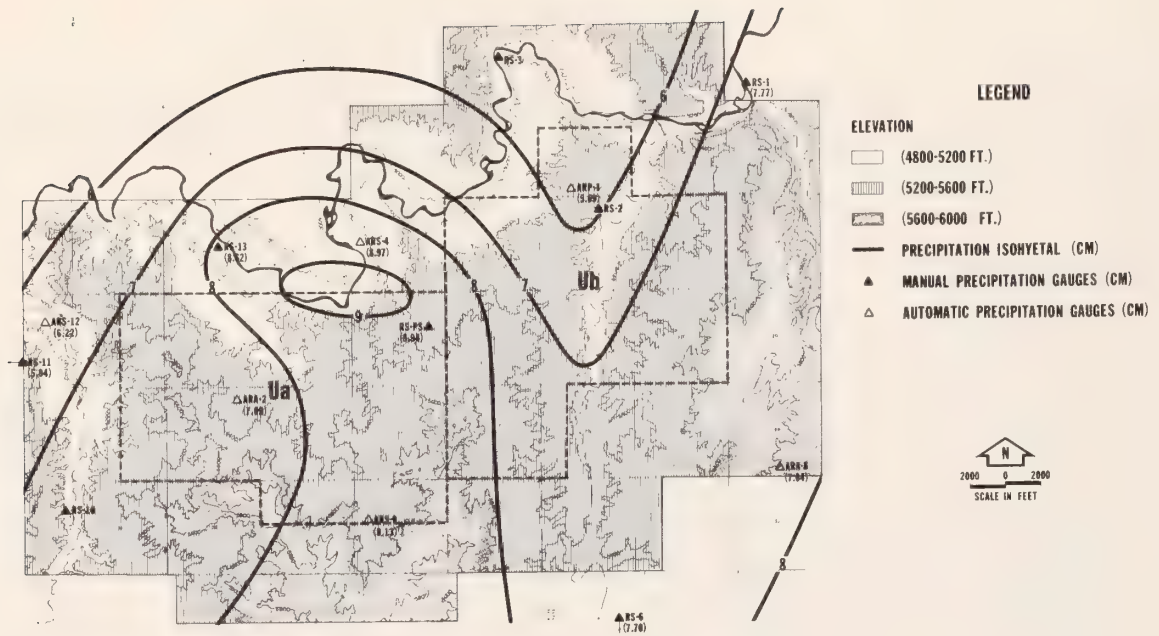


FALL PRECIPITATION
OCTOBER - NOVEMBER - DECEMBER - 1975

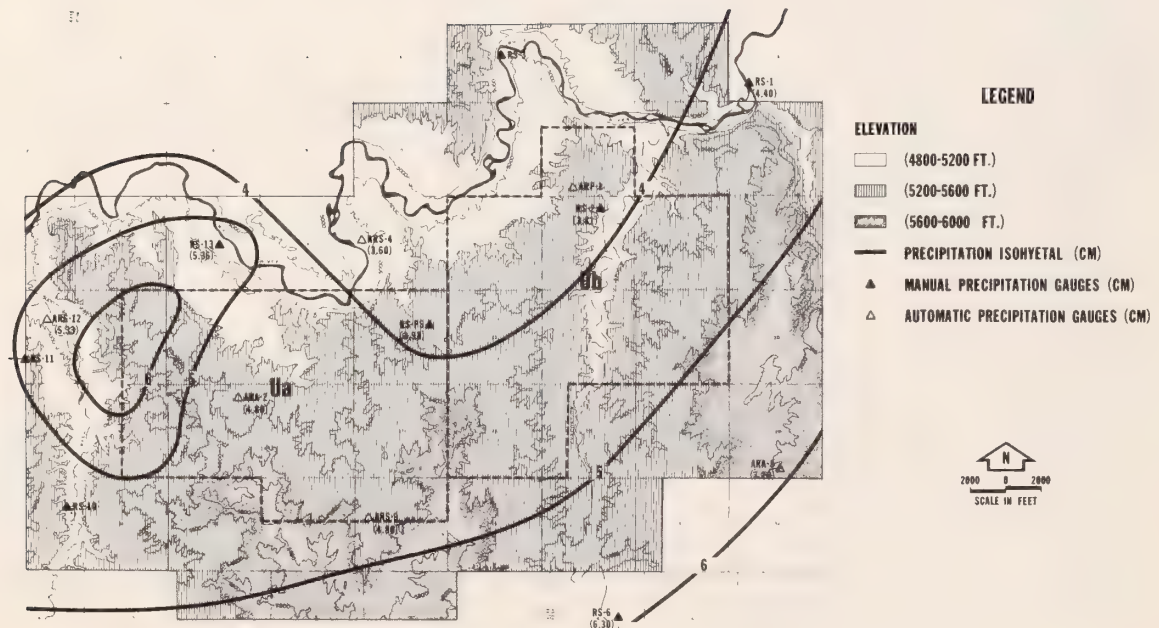


WINTER PRECIPITATION
JANUARY - FEBRUARY - MARCH - 1976

FIGURE II-6



SPRING PRECIPITATION
APRIL - MAY - JUNE - 1976



SUMMER PRECIPITATION
JULY - AUGUST - SEPTEMBER - 1976

FIGURE II-7

total precipitation than those of 1975. Because the lower rainfall in spring was not made up by heavier precipitation during the other seasons, 1976 was a drier year. Winter snow was evenly distributed during both years.

Streamflow

Streamflow on the tracts during the second year of the baseline program is discussed by the three major drainages within the study area: the White River, Evacuation Creek, and the washes.

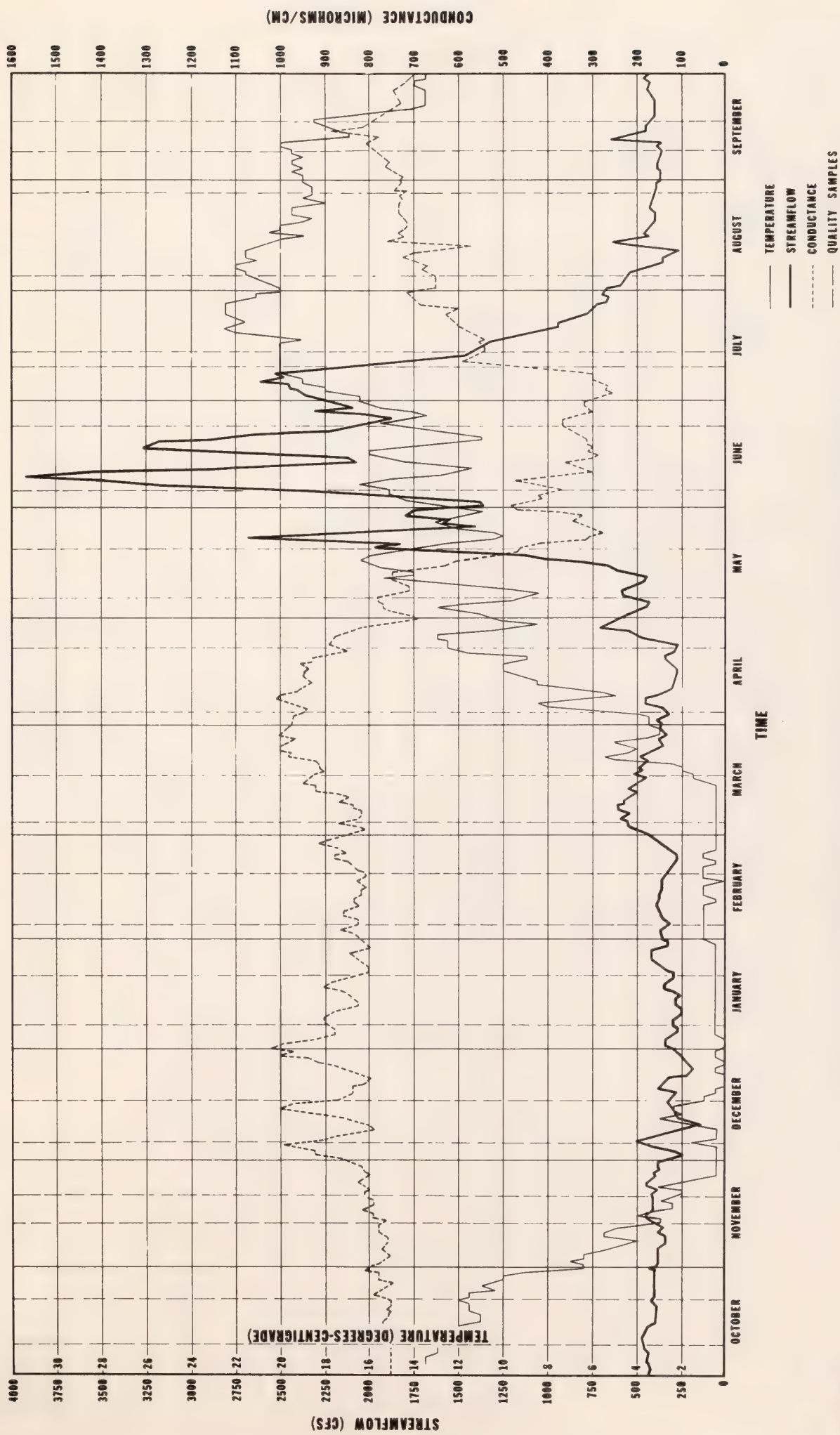
White River: Streamflow, specific conductance, and temperature in the White River during 1975 and 1976 are shown on figures II-8 through II-15. The hydrology of the White River is discussed in detail in the FYEBR. During the second year, streamflow conditions in the river were much the same as in the first, except that peak flows in 1976 were lower because of less snowpack in the mountains and therefore less runoff. In general, streamflow throughout 1976 was considered below normal based on 53 years of records collected at the USGS Ignatio station (S-3). Figure II-16 is a 20-year hydrograph for the USGS station.

The flow regime was similar to that of the preceding year, with base flow occurring between October and February from ground water seepage in the upper basin. Streamflow increased from late February through May as a result of snowmelt and rainfall runoff in the lower basin. Upper basin snowmelt began in mid-May, continued into July, with a return to base flow conditions by August.

Specific conductance and temperature are discussed here in terms of their importance in assessing hydrology and quality in the streams. Detailed discussions of these parameters for the three drainages are included in the FYEBR and therefore are not discussed here. The specific conductance and temperature trends described for the first year of monitoring continued during the second year.

Both specific conductance and temperature are important parameters to consider in studying the hydrology of a stream. Specific conductance is proportional to the dissolved solids content and can be used to determine the water source. For example, ground water seepage can often be identified because the levels of dissolved solids (and thus specific conductance) are typically higher in ground water than in surface runoff. Furthermore, ground water seepage occurs at a more or less constant rate throughout the year, while surface runoff varies with atmospheric conditions.

Water temperature is an indication of changes in stream conditions; for instance, when snowmelt runoff begins, the water



MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE

WHITE RIVER ABOVE HELLS HOLE CANYON - (S-1)

OCTOBER 1974 - SEPTEMBER 1975

FIGURE II-8



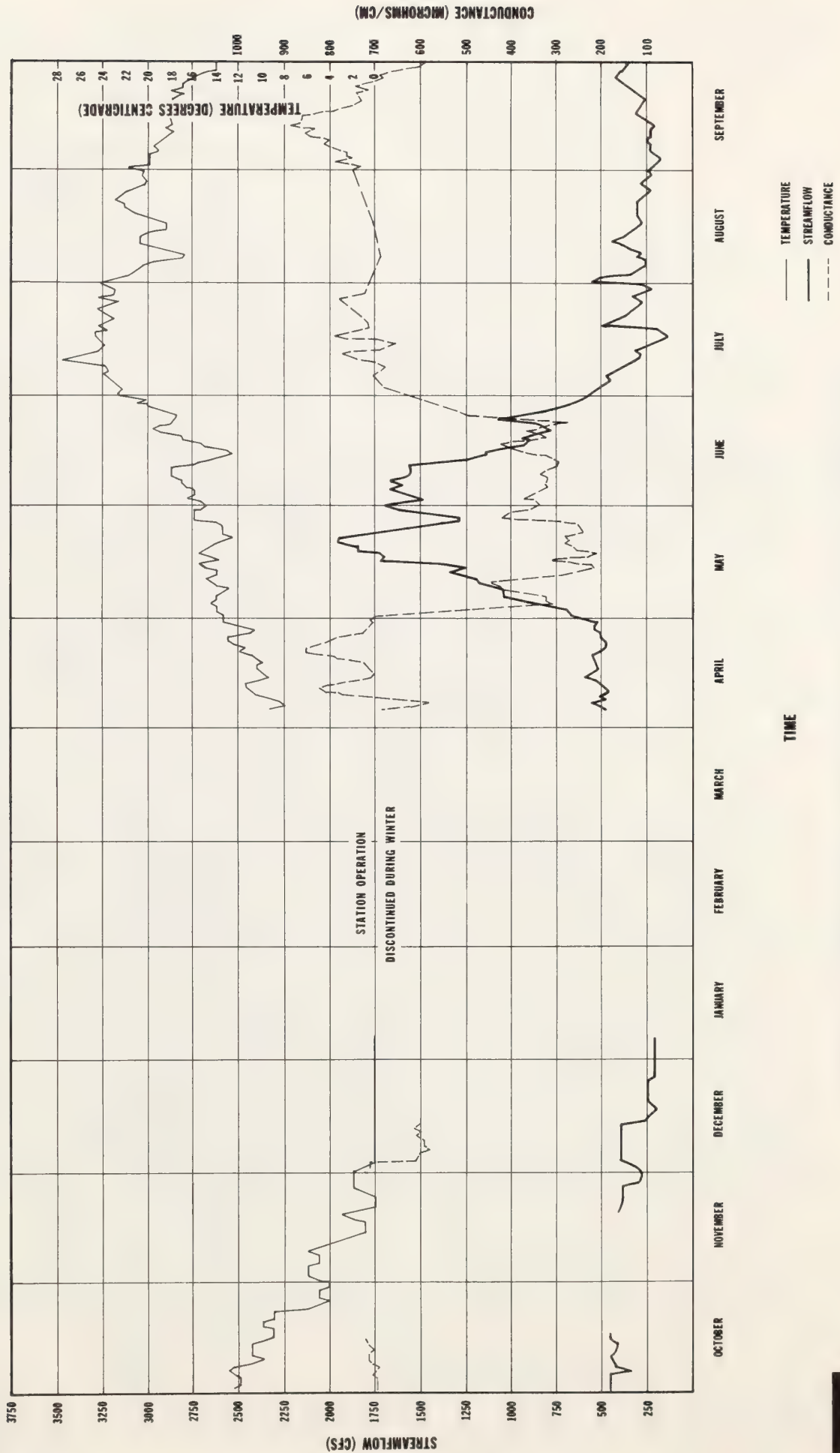
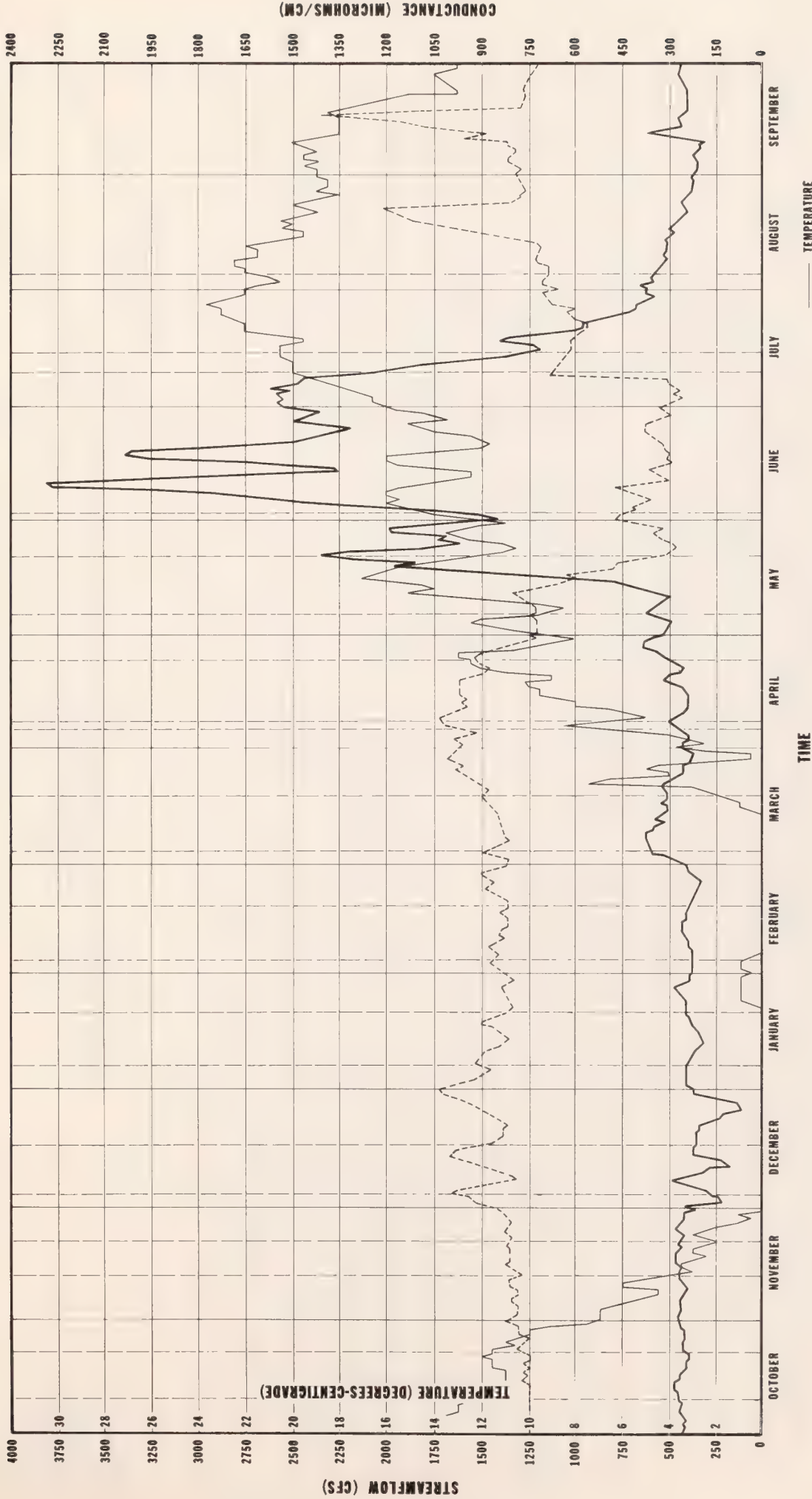


FIGURE 11-9



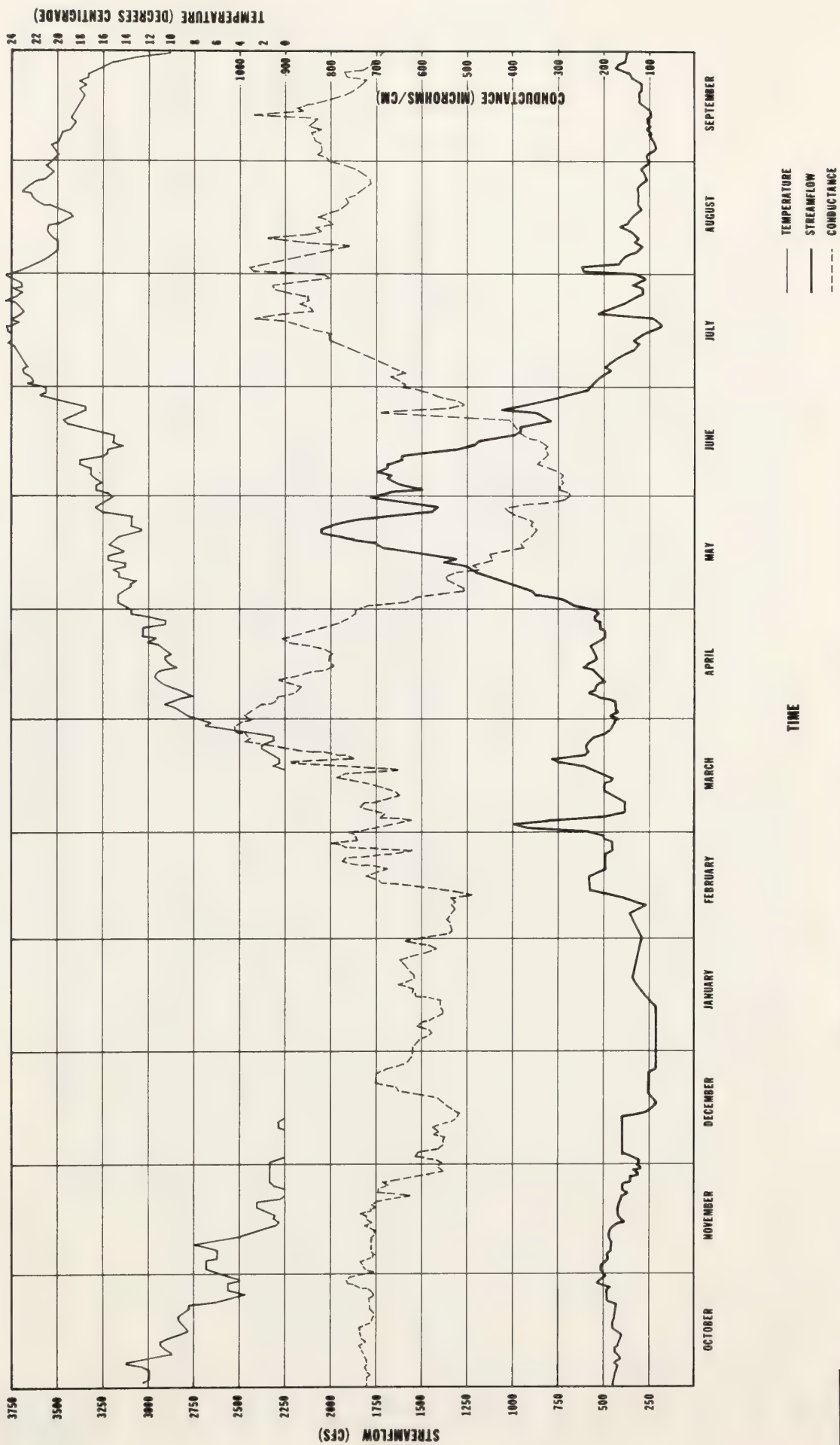


MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE

WHITE RIVER NEAR WATSON, UTAH - (S-3)

OCTOBER 1974 - SEPTEMBER 1975

FIGURE II-10

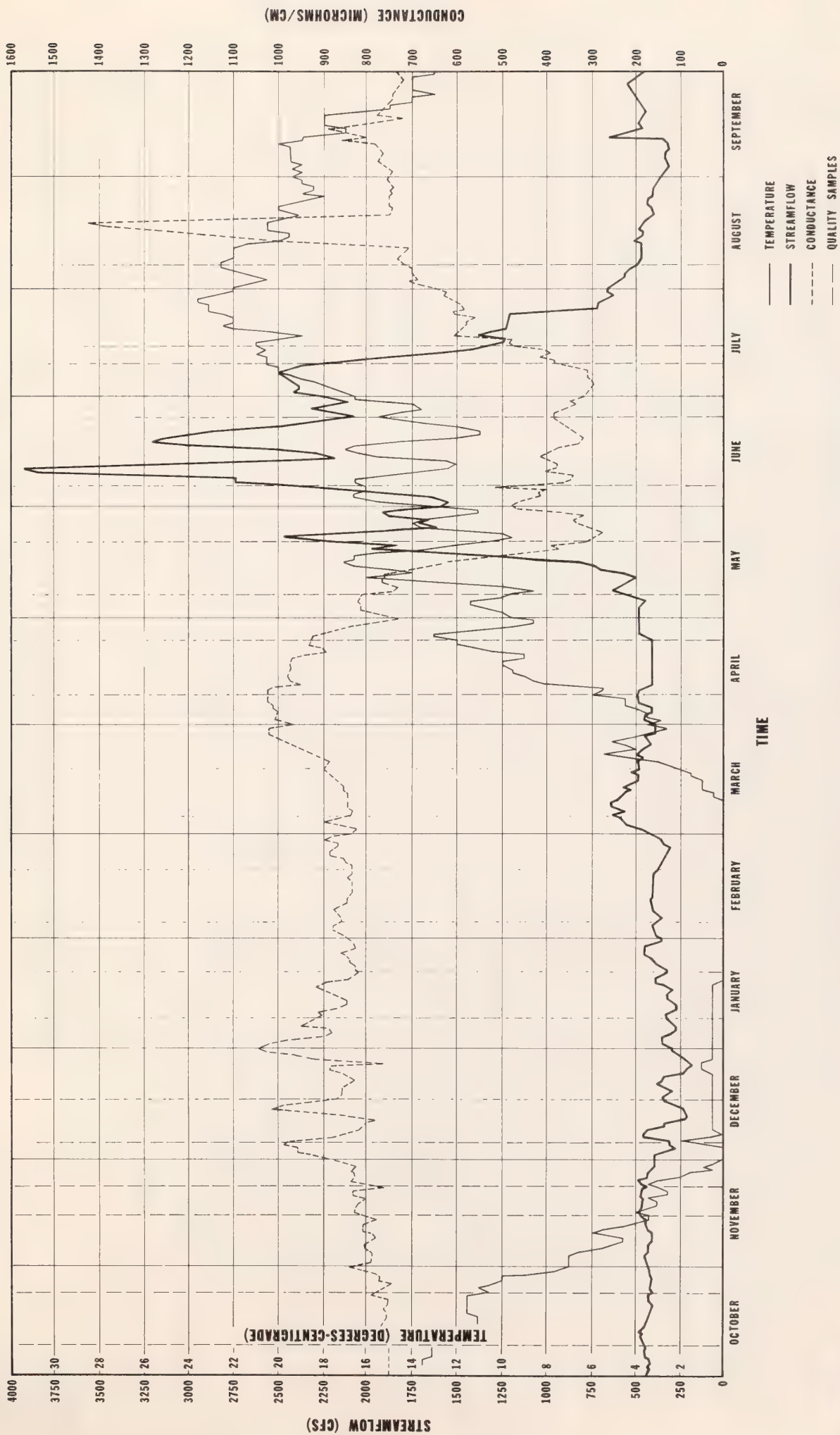


MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE

WHITE RIVER NEAR WATSON UTAH - (S-3)
OCTOBER 1975 - SEPTEMBER 1976

FIGURE II-11



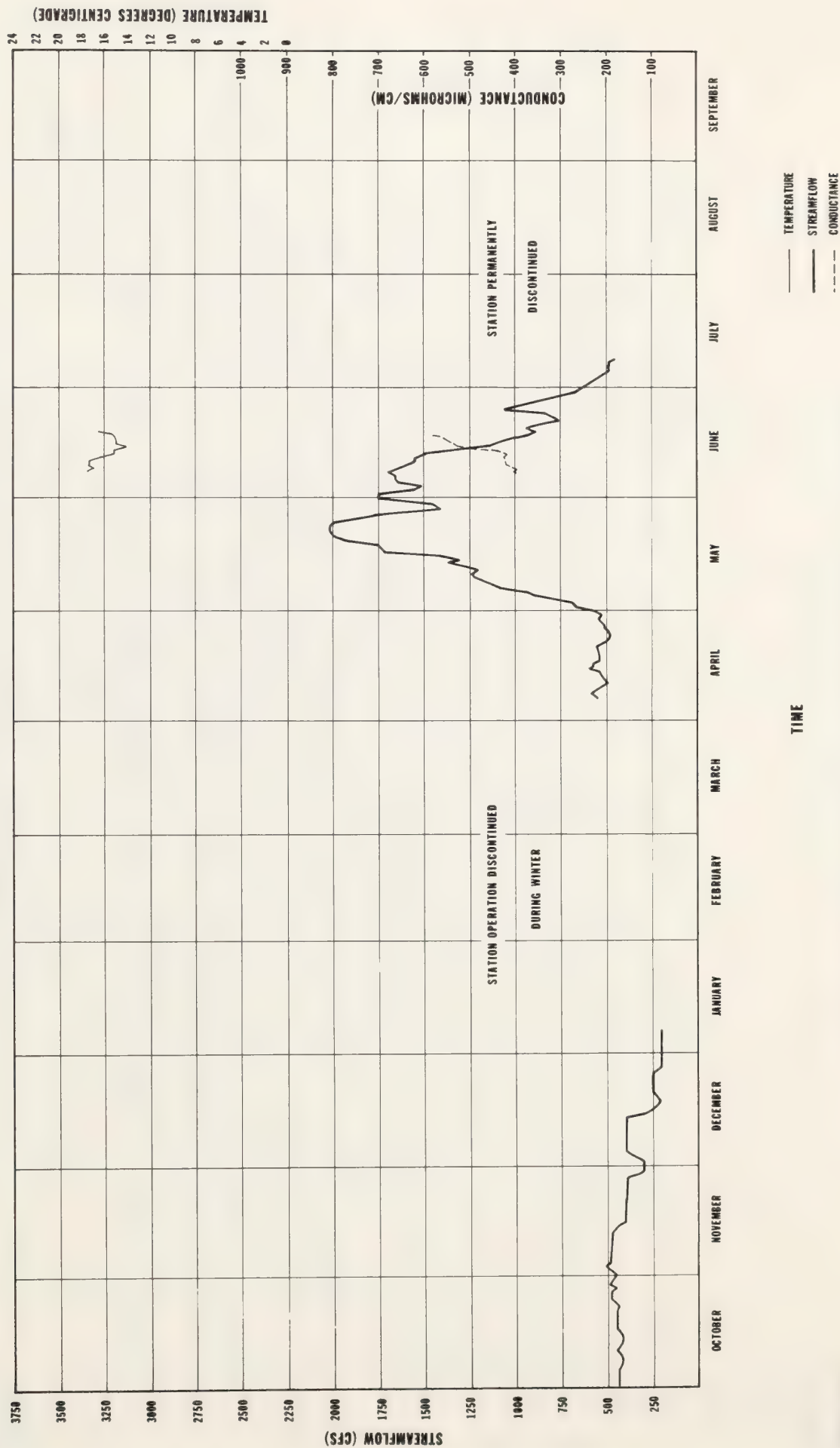


MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE

WHITE RIVER ABOVE SOUTHAM CANYON - (S-4)

OCTOBER 1974 - SEPTEMBER 1975

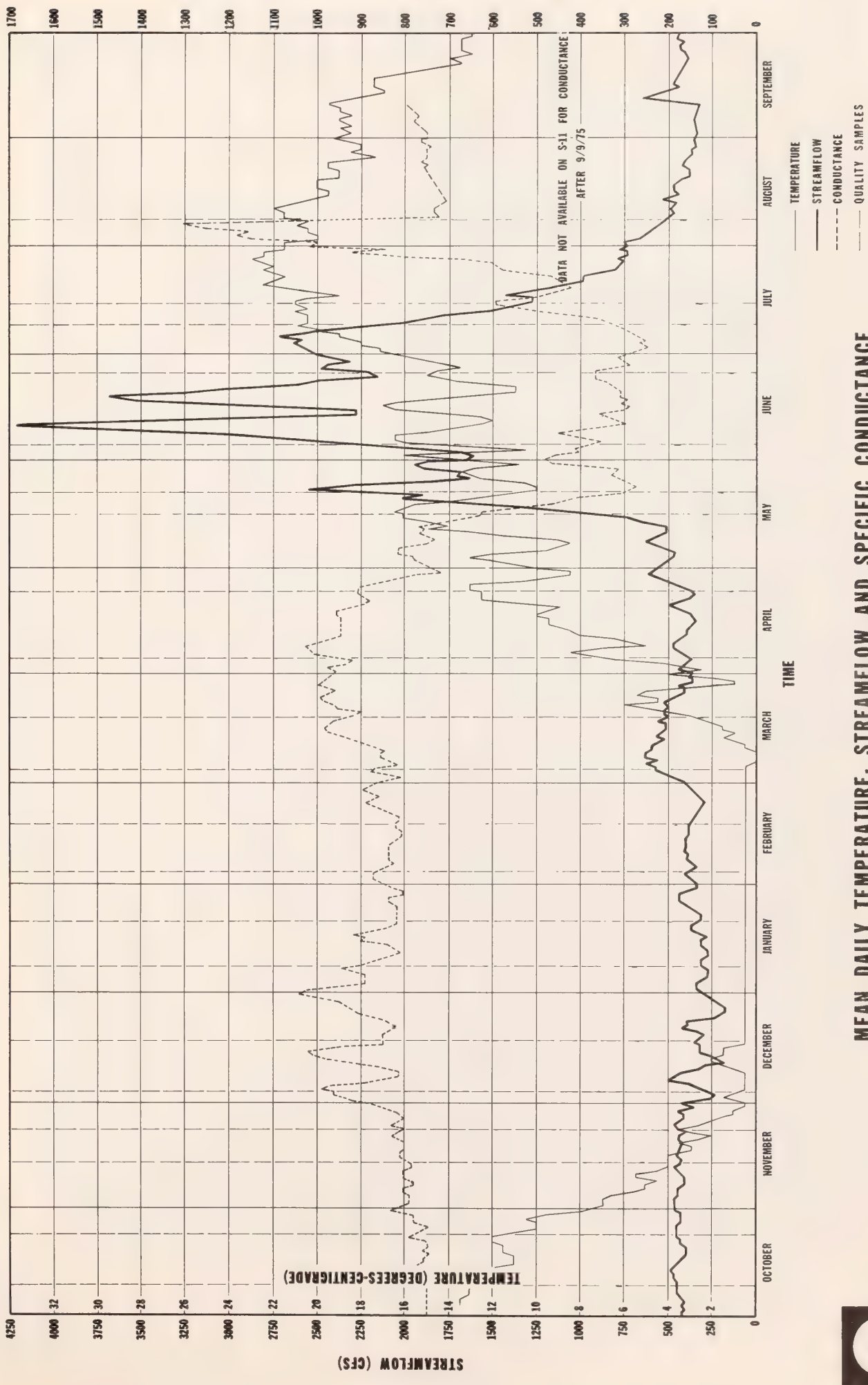
FIGURE II-12



MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE

WHITE RIVER ABOVE SOUTHAM CANYON (S-4)
 OCTOBER 1975 - SEPTEMBER 1976





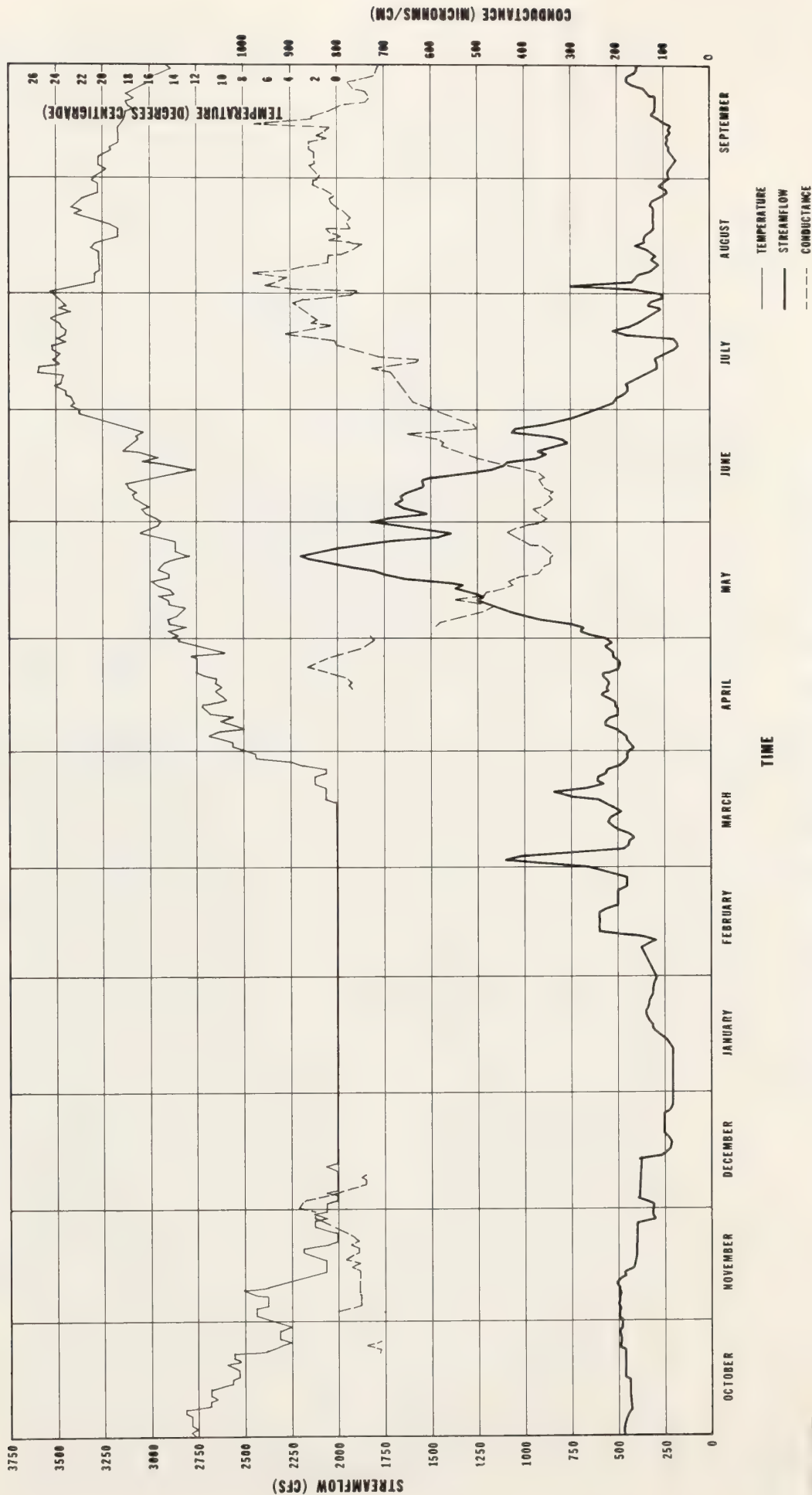
MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE

WHITE RIVER BELOW ASPHALT WASH - (S-11)

OCTOBER 1974 - SEPTEMBER 1975

FIGURE II-14



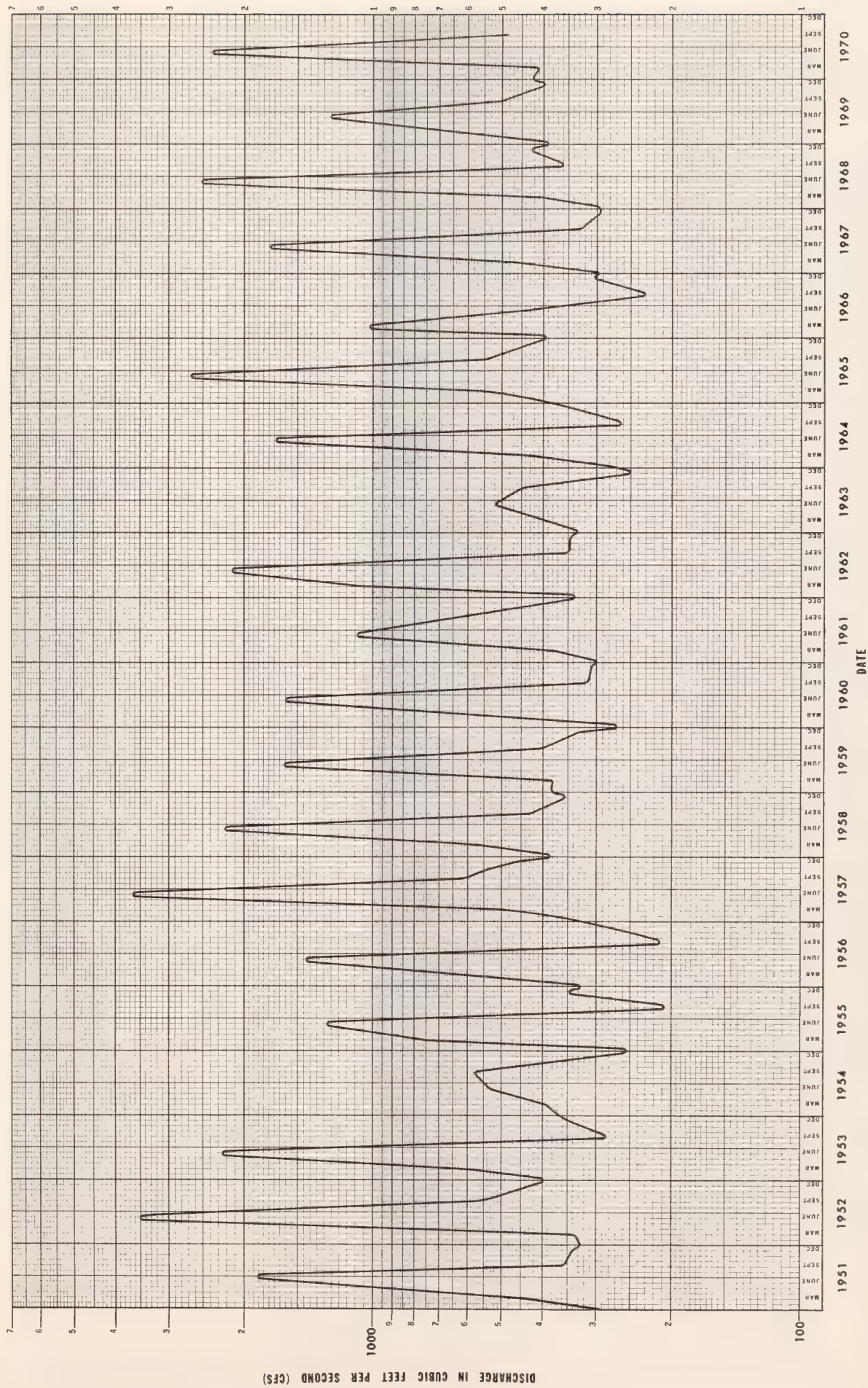


MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE

WHITE RIVER BELOW ASPHALT WASH, UTAH - (S-11)

OCTOBER 1975 - SEPTEMBER 1976





WHITE RIVER 20 YEAR HYDROGRAPH

WHITE RIVER NEAR WATSON (9-6500)

SOURCE: USGS

FIGURE II-16



temperature will drop sharply as the colder water enters the stream. Water temperature is also used to correct conductance measurements to the standard temperature of 25°C.

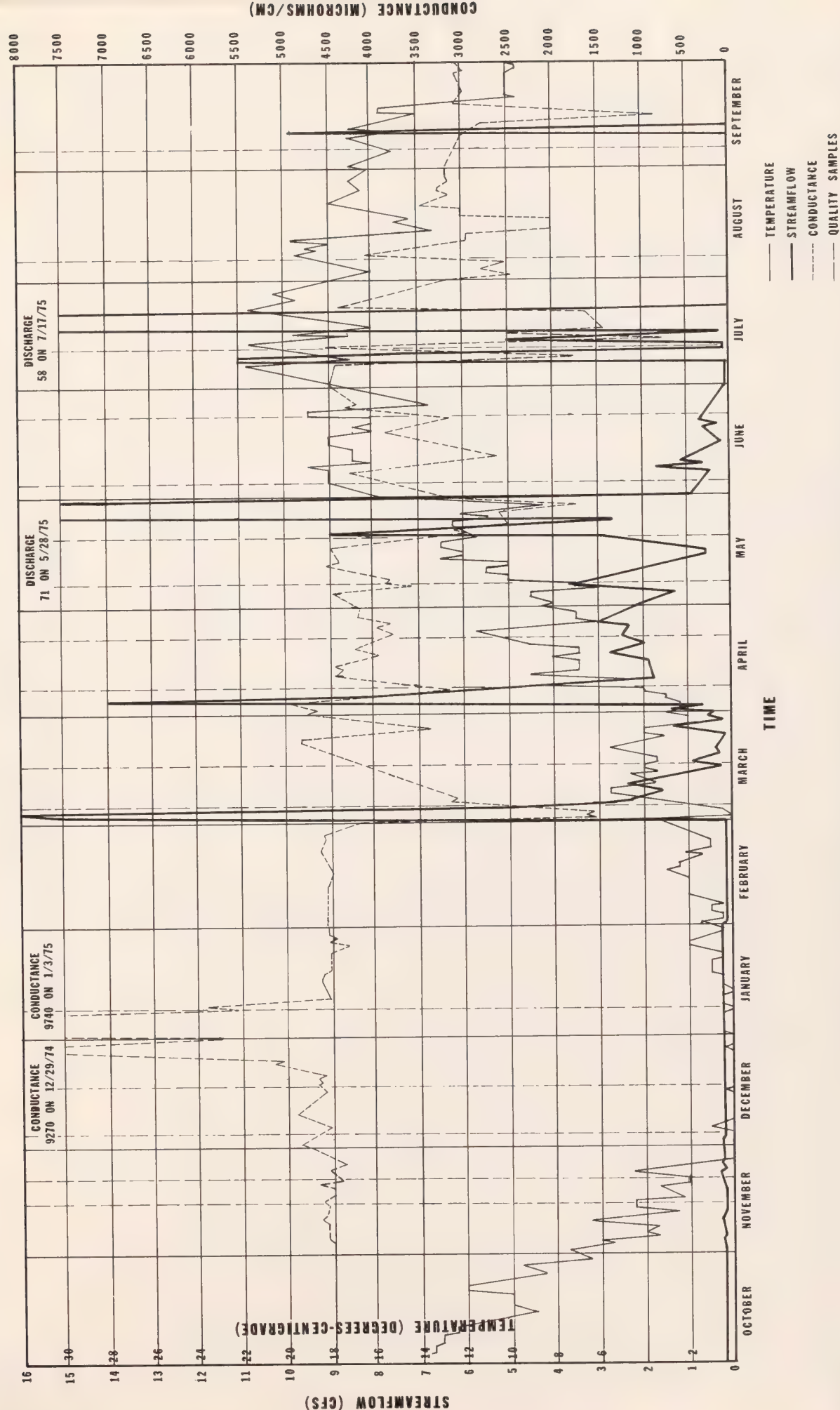
Evacuation Creek: Evacuation Creek, the only perennial stream on the tracts besides the White River, drains approximately 770 km² (280 sq mi). Initially, five stream gauging stations, three on the main stream and two on the tributaries, were established, but this number was decreased to two on the main stream (stations S-2 and S-6) when development plans excluded Evacuation Creek as a processed-shale disposal site. Stations S-7, S-8, and S-15 were deleted during the second year of monitoring.

Streamflow, specific conductance, and temperature for Evacuation Creek during 1975 and 1976 are shown on figures II-17 and II-21. With no historical records of conditions prior to the baseline study, historical streamflow conditions could only be estimated. It was assumed that since precipitation for the first year of monitoring was near the historical annual average, flow measured in Evacuation Creek during that time was also average; in that case, it is also likely that several reaches of the stream will be dry in years when precipitation is below average.

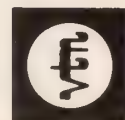
Peak flows of streams in arid regions are difficult to estimate because flows are related mainly to runoff from rainfall, which is more variable than that from snowmelt. Three methods -- two developed by the USGS and one by the SCS -- were used to estimate peak flows in Evacuation Creek. The results of these analyses are shown in the FYEBR. In addition, a flood-frequency analysis was performed using a method developed by the Utah Water Research Laboratory, which indicated that the maximum probable flood in Evacuation Creek would be 1030 m³/s (36,000 cfs).

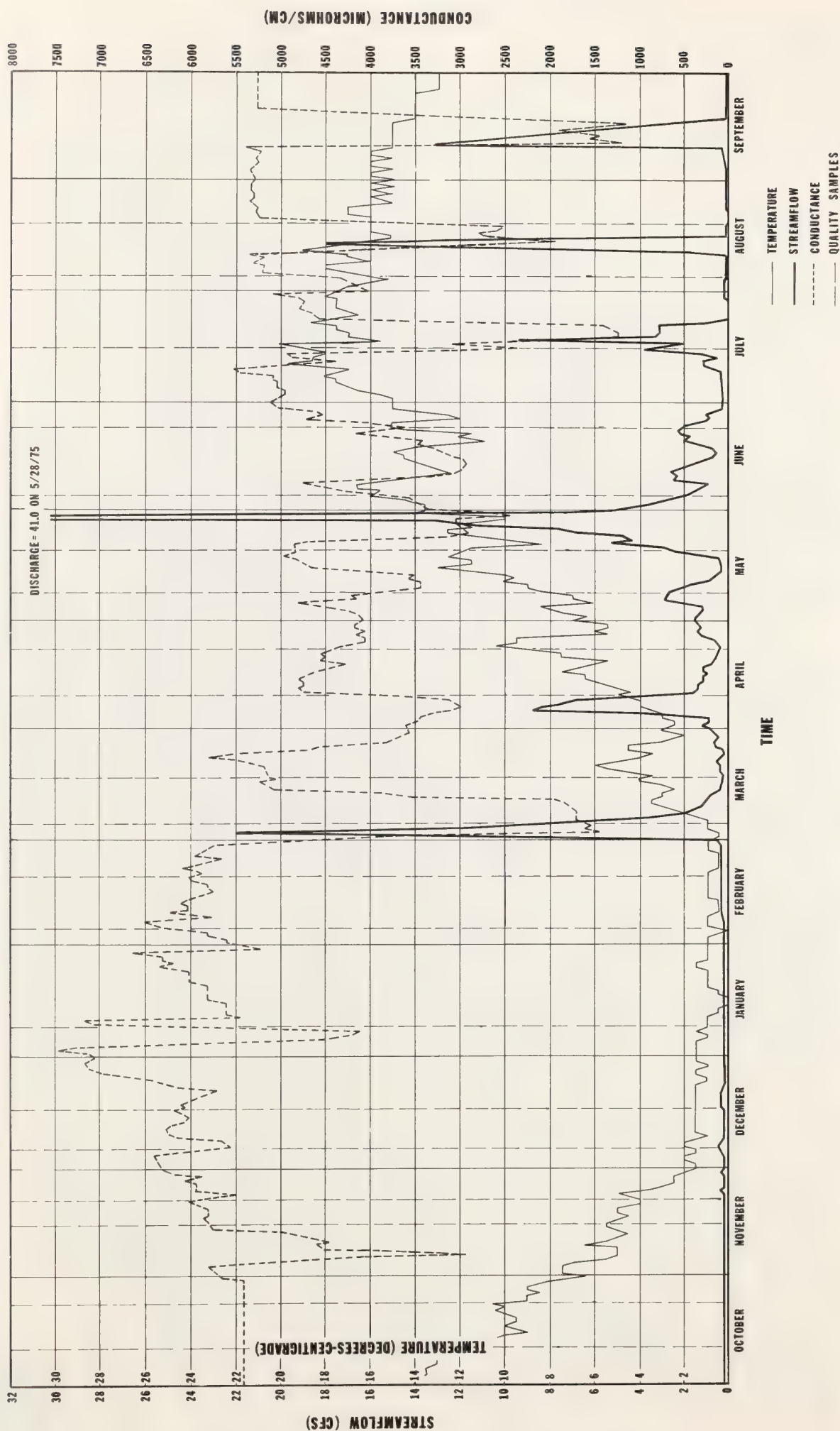
During the 1976 water year, the approximate total volumes of water passing the gauges on Evacuation Creek were 1270 ha-m (959 acre-ft) at S-6 (upstream of the tracts) and 1480 ha-m (1120 acre-ft) at S-2 (near mouth). There was no flow at any time during monitoring in the tributary canyons. The maximum mean daily streamflow was 2.5 m³/s (88 cfs), on February 10. Flows were occasionally less than 0.0003 m³/s (0.01 cfs) at both stations. Streamflow patterns and volumes were similar to those observed during the 1975 water year.

Flow patterns within Evacuation Creek are complex. Surface runoff contributes substantial amounts of water to the creek. During both years of monitoring, surface runoff was of short duration but very intense, and consequently it constituted between 60% and 90% of the flow. Peak flows were usually related to rainfall periods.



MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE
 EVACUATION CREEK BELOW PARK CANYON NEAR WATSON, UTAH - (S-7)
 OCTOBER 1974 - SEPTEMBER 1975





MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE

EVACUATION CREEK AT WATSON, UTAH - (S-6)

OCTOBER 1974 - SEPTEMBER 1975

FIGURE II-18



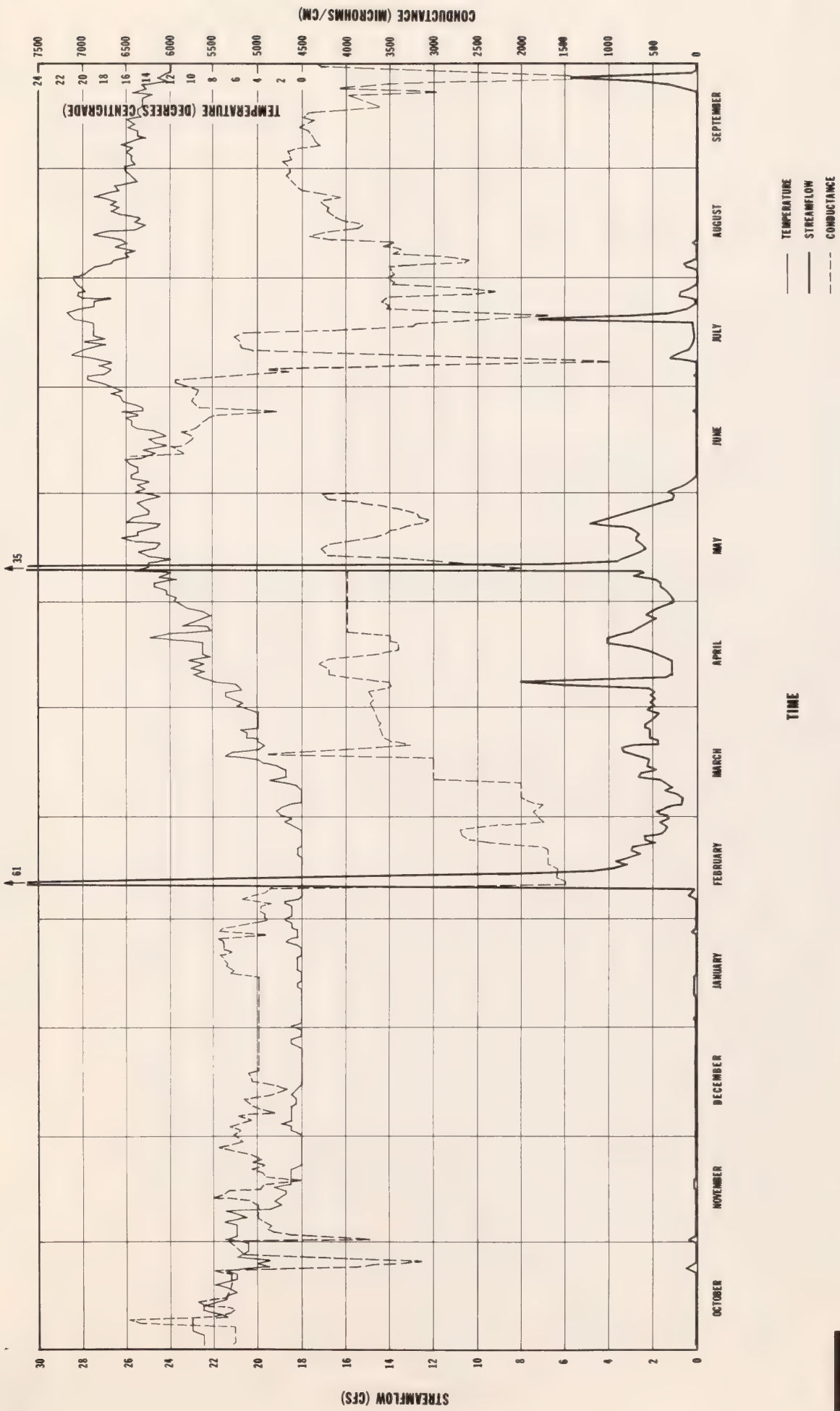


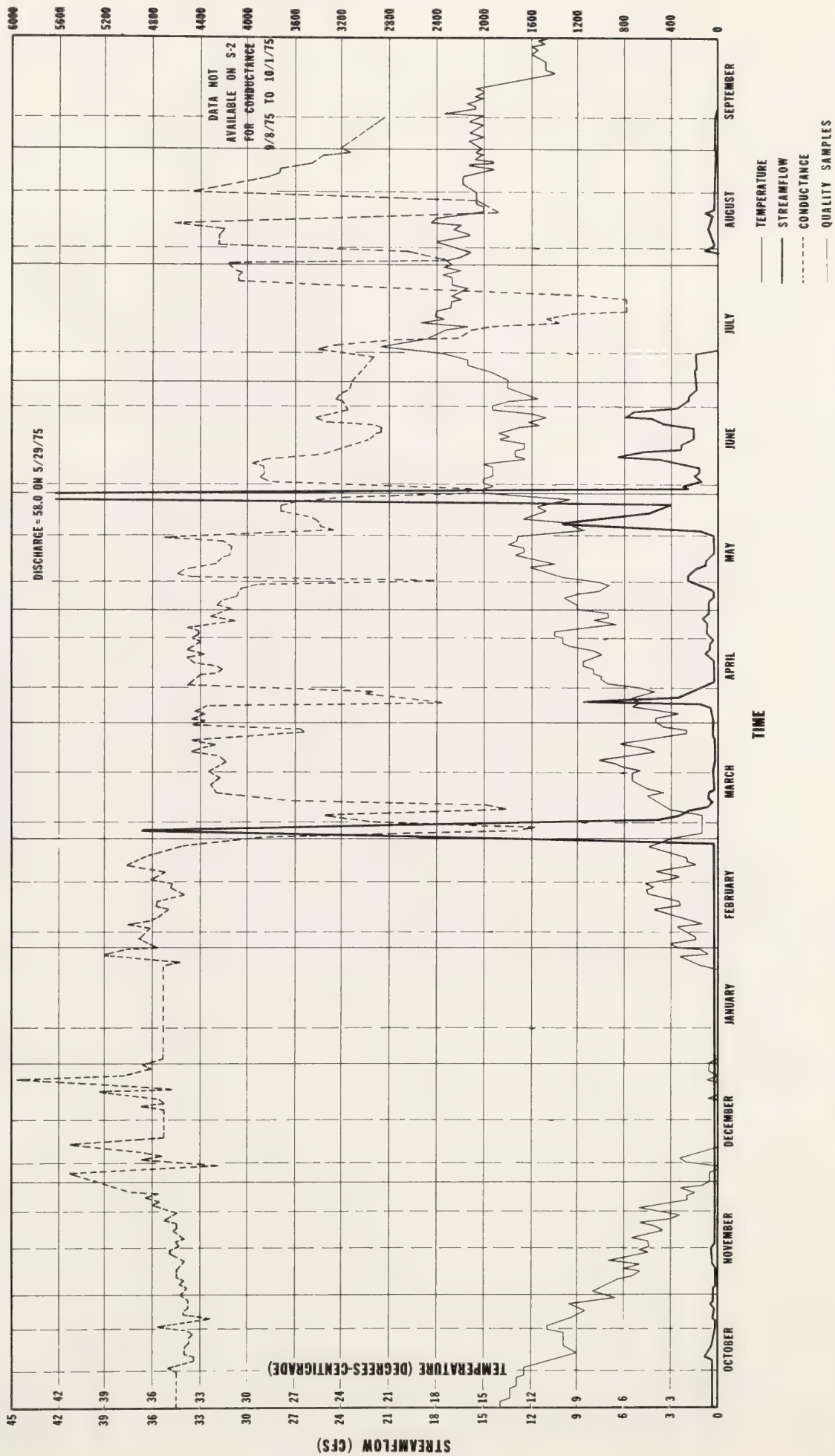
MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE

EVACUATION CREEK AT WATSON, UTAH (S-6)

OCTOBER 1975-SEPTEMBER 1976

FIGURE II-19

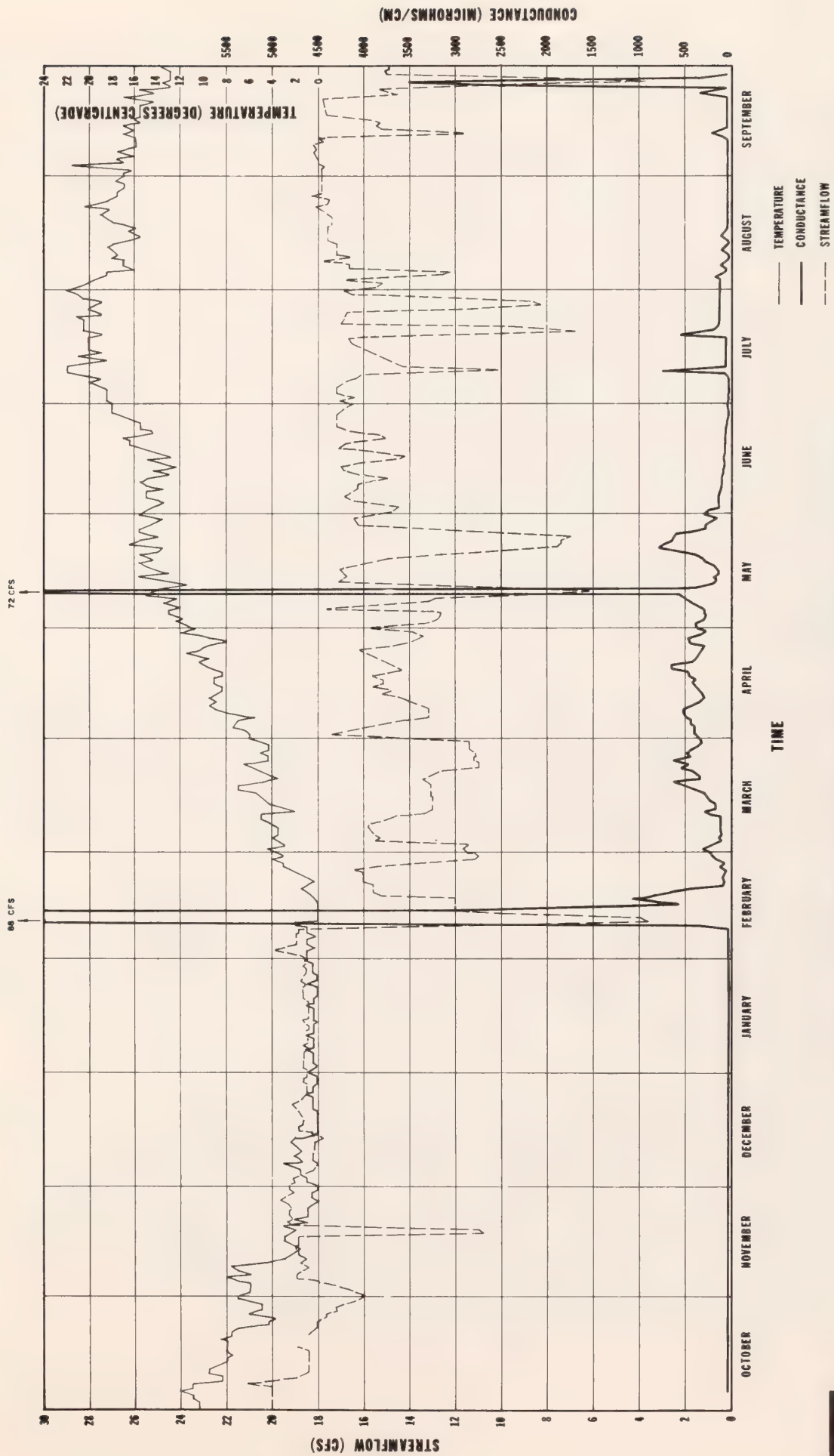




MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE

EVACUATION CREEK NEAR MOUTH BELOW WATSON, UTAH - (S-2)

OCTOBER 1974 - SEPTEMBER 1975



MEAN DAILY TEMPERATURE, STREAMFLOW AND SPECIFIC CONDUCTANCE
 EVACUATION CREEK NEAR MOUTH BELOW WATSON, UTAH - (S-2)
 OCTOBER 1975 - SEPTEMBER 1976

FIGURE II-21



Runoff from snowmelt contributed to flow only during the first part of March. The volume was considerably less than the annual snowfall would indicate: most of the precipitation was returned to the atmosphere through sublimation of snow crystals or evaporation of melted snow or was lost to the ground as soil moisture or aquifer recharge. Ground water seepage contributed less water than surface runoff (between 10% and 40%) but is a consistent source of flow in Evacuation Creek, with flow measured at both gauges for all but a few days of the year.

The chemical water quality samples collected at the gauge locations were similar enough to indicate that flow sources must be fairly continuous between the stations, although some intermediate stream sections appear to be dry. In these dry sections flow continued through other means, such as the stream alluvium or the bird's nest aquifer where it contacts the stream. The gauges were placed at points where some of the water flowing in the alluvium was forced to the surface, so that the gauges measured both the surface flow and the alluvial flow forced to the surface. In the section between stations S-7 and S-6, the streambed is occasionally dry, but it is assumed that ground water flow continues in the alluvium. Between stations S-6 and S-2 both the surface and possibly the alluvium are occasionally dry and flow continues through the bird's nest aquifer.

The Dry Washes: Southam Canyon, Hells Hole Canyon, and Asphalt Wash flow irregularly and briefly. Southam Canyon is the most relevant to the study, since about 12 km² (5 sq mi) of its 23 km² (9 sq mi) of drainage area is within Tract U-a. Hells Hole Canyon drains about 70 km² (26 sq mi), none of which is within either tract; and Asphalt Wash drains about 264 km² (100 sq mi), about 2.5 km² (1 sq mi) of which is within Tract U-a.

Several gauging stations were installed to measure streamflow within these washes. One station is at the mouth of Hells Hole Canyon (S-5), and stations are located upstream and downstream of the tracts on Southam Canyon (S-9 and S-13) and Asphalt Wash (S-10 and S-12). The flows measured at these stations in 1975 are listed in the FYEBR; flows in 1976 are listed on Table II-1.

Flow from the washes varied between the two years of monitoring. The total flow from Asphalt Wash was 22 ha-m (17 acre-ft) in 1975 and 35.7 ha-m (27 acre-ft) in 1976, representing a 23% increase over the previous year. Total flows from Hells Hole and Southam canyons, on the other hand, decreased dramatically in 1976. In Hells Hole Canyon flow decreased 97%, from 370 ha-m (280 acre-ft) in 1975 to 12.2 ha-m (9.12 acre-ft) in 1976; in Southam Canyon flow decreased 76%, from 28 ha-m (21 acre-ft) in 1975 to 6.7 ha-m (5.1 acre-ft) in 1976.

TABLE II-1
HELLS HOLE CANYON, SOUTHAM CANYON, AND ASPHALT WASH STREAMFLOW RECORDS
m³/s (cfs)

STATION		OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JUL	AUG	SEPT
S-5 Hells Hole Canyon	Number of												
	Days of Flow	0	0	0	0	3	1	0	3	2	1	1	4
	Mean Daily Flow During Event					.006 (0.21)	.0003 (0.01)		.0073 (0.26)	.0141 (0.5)	.0183 (.65)	.0112 (.40)	.0125 (0.445)
S-9 Southam Canyon	Number of												
	Days of Flow	0	0	1	0	3	0	0	0	0	0	0	0
	Mean Daily Flow During Event	.0056 (.20)		.0003 (.01)									
S-13 Southam Canyon At Mouth	Number of												
	Days of Flow	0	0	1	0	3	0	0	0	1	0	0	1
	Mean Daily Flow During Event			.0008 (.03)		.0062 (.22)				.0506 (1.8)			.0014 (.05)
S-10 Asphalt Wash	Number of												
	Days of Flow	0	0	0	0	4	0	0	0	1	0	0	2
	Mean Daily Flow During Event					.0506 (1.8)				.0028 (.10)			.0232 (.825)
S-12 Asphalt Wash At Mouth	Number of												
	Days of Flow	0	0	0	0	6	0	0	0	1	0	0	4
	Mean Daily Flow During Event					.0333 (1.183)				.1237 (4.4)			.0155 (.5525)

Other aspects of the washes were equally as variable as stream-flow. Although there was less precipitation in 1976, the individual storms were more intense, which should have brought more runoff; instead, there was actually less runoff than in 1975. Also, flow in 1976 was much less than that predicted in the FYEBR. These inconsistencies emphasize that the behavior of desert washes is difficult to predict and that any such estimates, such as the flood-frequency figures calculated in the FYEBR, should be considered preliminary guidelines only and thus used with caution.

c. Interpretation and Conclusions

During the two years of monitoring, each of the three main surface hydrologic systems on the tracts has shown distinct periodic trends, both in the sources of flow and in the times of the year each source has contributed to the system. These trends are the basis on which the physical hydrology and quality of the water resources on the tracts have been interpreted.

The White River is subject to several such trends: a baseflow period, (approximately August through February) in which the two year average flow of $11\text{m}^3/\text{s}$ (380 cfs) is sustained by ground water seepage mainly from above Meeker, Colorado; a lower basin runoff period (late February through April) in which surface runoff from drainage below Meeker contributes substantial flow (average flow of $15\text{m}^3/\text{s}$ [530 cfs]); and an upper basin runoff period (May through July) in which snowmelt from the mountains above Meeker produces the annual maximum flow (average flow of $41\text{m}^3/\text{s}$ [1430 cfs]). Evacuation Creek has two distinct trends--a baseflow period, (between August and February) in which flow is sustained by seepage from aquifers, including the bird's nest aquifer, and a high flow period, (March through July) in which flow is increased substantially by snowmelt and rainfall runoff. The actual dates of these periods fluctuate from year to year. Flow in the washes is intermittent and usually of very short duration, from either snowmelt or rainfall.

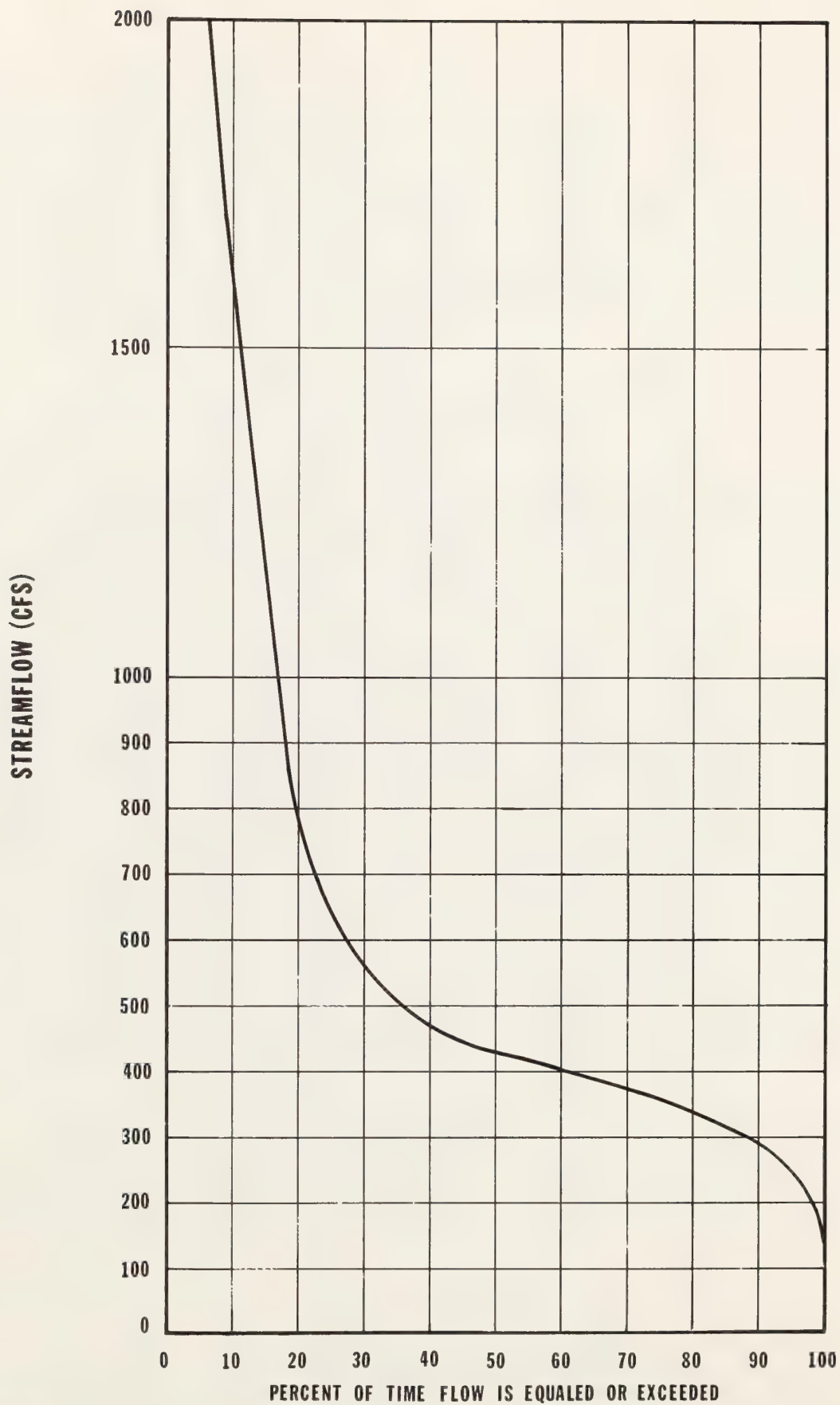
The times of the year in which these periods have occurred in each of the systems during baseline monitoring are shown on Table II-2. The streamflow characteristics during these periods within each hydrological system are discussed in more detail below:

White River

The annual low and peak flows in the White River on the tracts are discussed in the FYEBR. An additional flow-duration curve (Figure (II-22)) was plotted from a USGS publication,

SOURCES AND PERIODS OF FLOW
WHITE RIVER, EVACUATION CREEK, AND THE WASHES

II-30



WHITE RIVER FLOW - DURATION RELATION

SOURCE: U.S.G.S. UTAH BASIC DATA RELEASE NO. 25



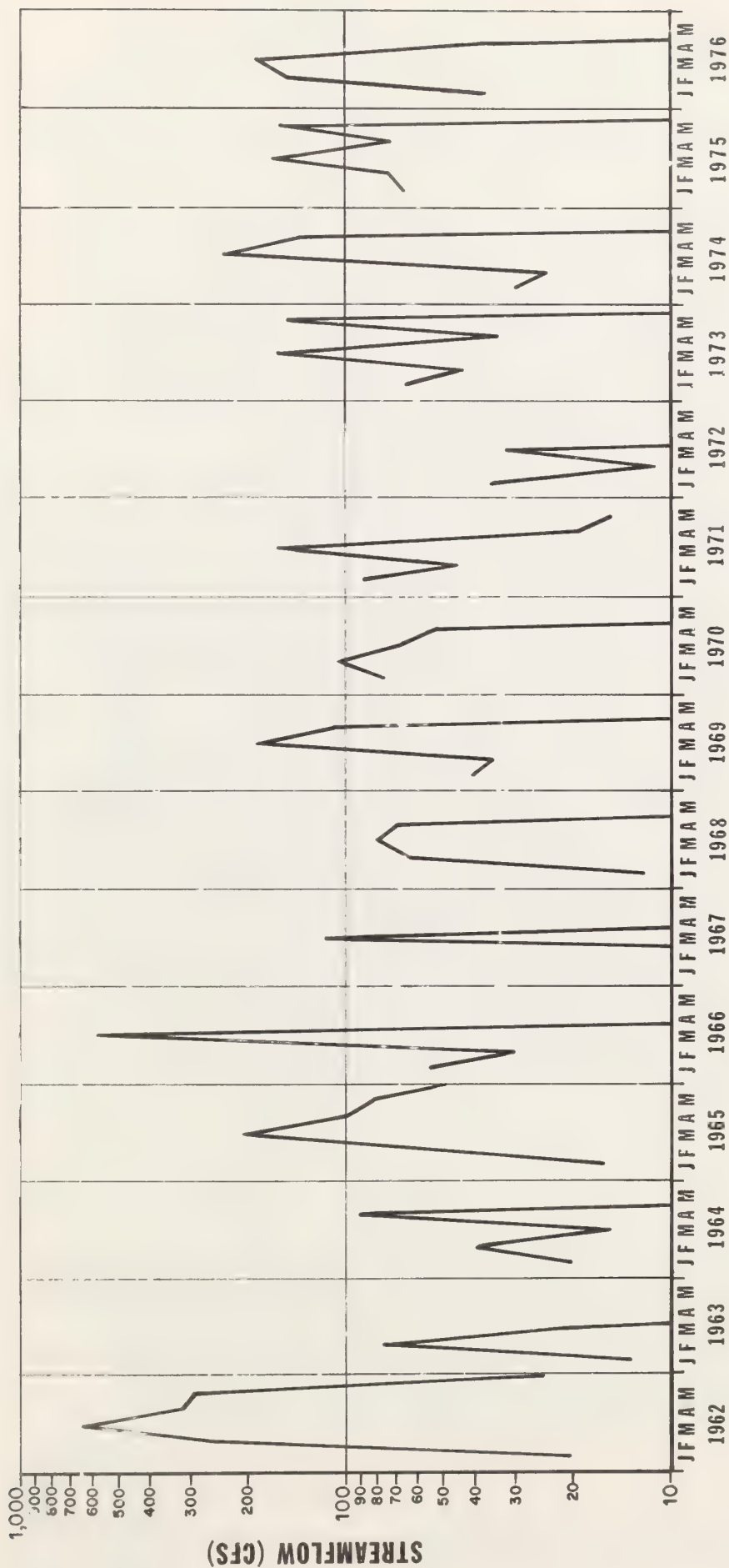
Streamflow Characteristics of Northeastern Utah and Adjacent Areas (Fields 1975). Baseflow is represented by the flat area of the curve between 50% and 90%. Lower and upper basin runoff is usually to the left of 50%. The portion of the curve between 90% and 100% represents increasingly long-term drought conditions during which the aquifers supplying seepage would be depleted.

It should be noted that during the second year of monitoring it was demonstrated that the apparently random fluctuations in daily flow were not random at all. Comparison of the records at Meeker, which is below the source of much of the flow, but above the tracts, shows similar patterns, but shifted in time. It would be possible to establish travel time versus discharge by applying cross correlation techniques to historical records. These techniques could also be used to cross-correlate flow with conductivity in the White River in the study area. The inverse correlation between flow and conductivity (i.e., increased flow, decreased conductivity) has been established; the additional analysis would determine whether there is a lag time between them, which would imply that the patterns of river stage and conductivity are moving at different speeds. Knowing the patterns of both conductivity and flow at Meeker and in the study area, the source of flow could be identified within a few kilometers. Such detailed analysis would require considerable additional work and a longer period of historical record.

Although the sources of baseflow and upper basin runoff in the White River are well removed from the tracts and are therefore beyond the scope of the project, the lower basin runoff is from drainage which includes the project area. The historic monthly volume of lower basin flow contribution to the White River was estimated by calculating the difference between monthly flow at Meeker and flow at the tracts. Interferences such as ice formation in the river in January, February, and March, and withdrawal of water for irrigation in March, April, and May probably cause these estimates to differ from the actual flows by as much as 50%, and so they should be used with caution; however these calculations (shown on Figure II-23) definitely show that lower basin runoff in the White River is quite variable in time of occurrence and volume.

Evacuation Creek

The monthly flow during the high flow period in Evacuation Creek corresponded well with that of lower basin runoff in the White River throughout the baseline study, indicating that high flows in Evacuation Creek were about normal during the two years of monitoring. The baseflow period is the time when the interaction between the bird's nest aquifer and Evacuation Creek is the most evident. Further assessment of the hydrology



LOWER BASIN RUNOFF

FIGURE II-23



and quality of Evacuation Creek and the aquifer indicates that both the unusual stream conditions between stations S-2 and S-6 and the aquifer characteristics and quality of the bird's nest aquifer are caused by the interaction of surface and ground waters. In the bird's nest aquifer this interaction is the most noticeable in the shift towards an oxydized system (ground water is typically a reduced system) in the northeast sector, as opposed to the reduced system in the southwest sector. This shift occurs when flow from the aquifer, generally to the northwest, interacts with the surface water where Evacuation Creek flows across the aquifer outcrop.

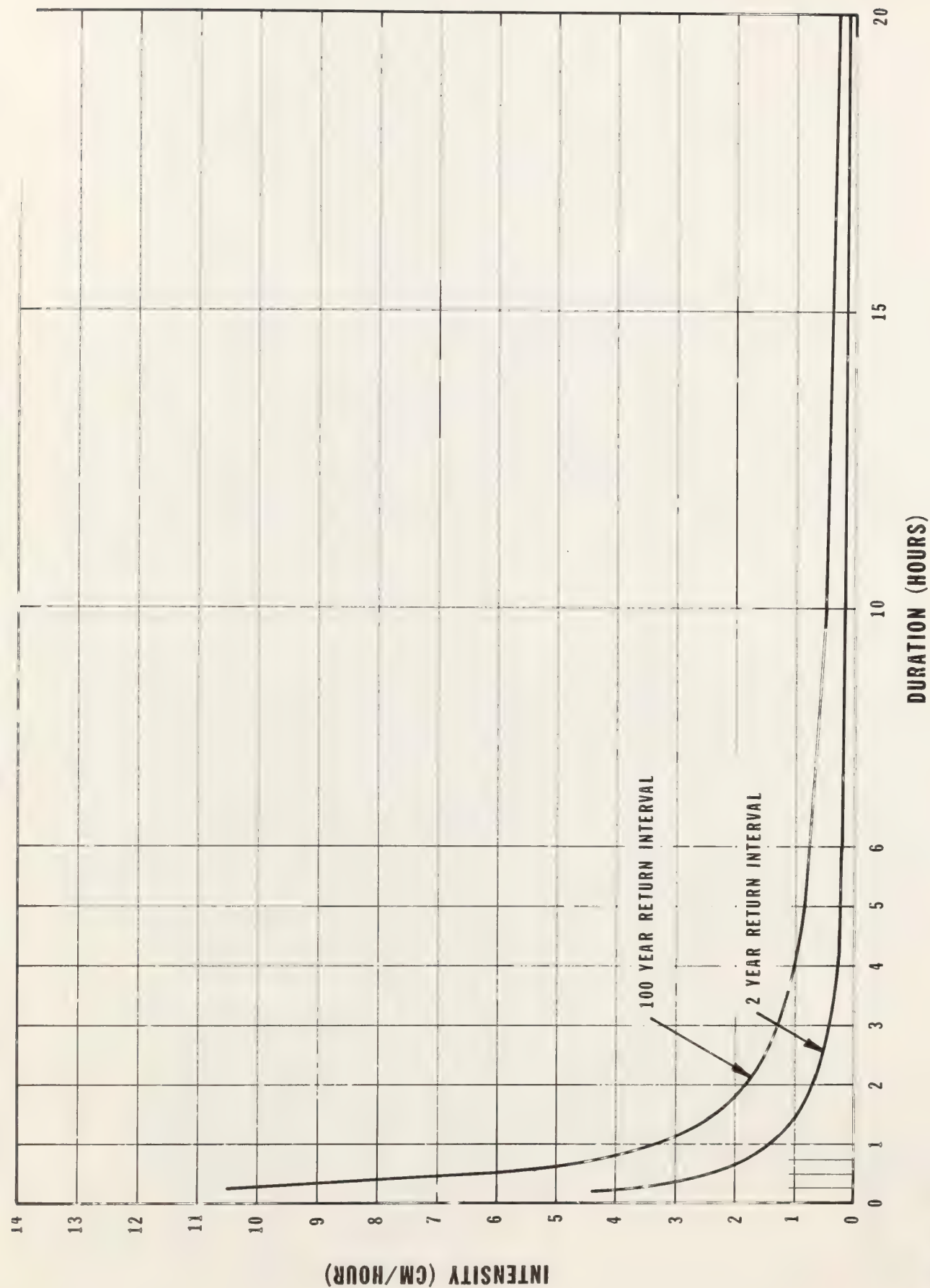
During both years in Evacuation Creek, streamflow and the dissolved solids content decreased between station S-2 and S-6. This is an unusual phenomenon during baseflow, when the dissolved solids content of a stream generally increases. A plausible explanation for this is found in the slight shift towards a reduced system at Station S-2, which indicates that water from the bird's nest aquifer is flowing into Evacuation Creek. Since the flow in Evacuation Creek does not increase, it must be losing water to the bird's nest aquifer. The mixing of water from the two sources causes chemical reactions which precipitate matter and thus decreases the dissolved solids concentration. This interaction is discussed further in Section II.A.2.c., "Interpretation and Conclusions."

The Dry Washes

The washes were unpredictable during the baseline study. Precipitation in most areas during the second year was slightly less than during the first year, although individual storms had more rain. It would be logical that the bigger storms would produce more runoff, but in two of the three washes there was actually less runoff during the second year. Apparently, total precipitation alone is a poor indication of runoff amounts; instead, there are other variables that have considerable influence such as rainfall intensity, soil moisture, topography, basin aspect, and storm path. During the two years of monitoring, runoff in the washes was associated only with storms having intensities of more than 0.5 cm/hr sometime during the event, and therefore it is likely that intensity is the key factor.

Precipitation intensity, duration, and frequency for the tracts are graphed on Figure II-24. An attempt to extend the monthly record at the tracts by correlating them with those of the Bonanza station was unsuccessful. Although the correlation coefficient between Station ARP-1 and Bonanza was high (0.91), the 90% prediction interval was too wide (about ± 0.8 cm) to be able to extend the records; for Station ARS-9 the correlation coefficient was questionable (0.67) and the 90% prediction

RAINFALL INTENSITY, DURATION AND FREQUENCY OF OCCURRENCE



interval was again too broad. As a result, the records could not be extended with any accuracy, apparently because the individual storms that affect the quarterly pattern were too sporadic, (i.e., producing rainfall unevenly throughout the area).

Between 1908 and 1938 a station was operated near Watson. Unfortunately this record overlaps the Bonanza record for only six months, so it could not be extended forward.

2. WATER QUALITY

a. Methodology

The methodology used to study water quality on the tracts during the second year was the same as that used during the first year, except for the addition of dissolved organic carbon (DOC) fractionation analysis. Some samples collected during January, February, and March were analyzed by a laboratory other than that used previously, but because of questionable results, the data were not used in developing this report.

b. Summary of Results

As part of the surface hydrology analysis, sampling was conducted for a broad range of constituents, as categorized on Table II-3. Although not all of these elements are shown in the chemographs, which are part of the following discussion, they are included in the summary tables presented in Section II.A.2.c., "Interpretation and Conclusions." The reader may wish to refer to these tables (Table II-11 for the White River, Table II-12 for Evacuation Creek, and Table II-5 for the washes) in conjunction with the following discussion. For comparison, the water quality criteria and standards used in the discussion are summarized on Table II-4.

Water quality constituents are broadly classified as suspended solids and dissolved solids. The amount of suspended solids measured as suspended sediment usually varies directly with streamflow, since increases in flow are usually associated with increases in surface runoff from rainfall or snowmelt, which carry soil and other material into the stream. Since ground water seepage carries little suspended matter, suspended sediment concentrations are usually lowest during baseflow.

Fluctuations in dissolved solids concentrations correspond inversely to changes in streamflow because concentration levels are dependent on the volume of flow and the duration of mineral

TABLE II-3

CONSTITUENTS SAMPLED IN
SURFACE HYDROLOGY PROGRAM

General Characteristics

Alkalinity	*Specific Conductance
-Dissolved Solids	*Streamflow
Hardness	-Suspended Sediment
Non-Carbonate Hardness	*Temperature
-pH	Oil and Grease

Major Cations

Major Anions

-Calcium	-Bicarbonate
-Magnesium	Carbonate
Potassium	-Chloride
-Sodium	-Sulfate
SAR (sodium absorption ratio)	Sulfide
Percent Sodium	-Fluoride
Strontium	Bromide

Biochemical Constituents

Carbon Dioxide	TIC (Total Inorganic Carbon)
-Dissolved Oxygen	DOC (Dissolved Organic Carbon)
BOD (Biochemical Oxygen Demand)	-Total Coliforms
-COD (Chemical Oxygen Demand)	Fecal Coliforms
SOC (Suspended Organic Carbon)	Fecal Strep
TOC (Total Organic Carbon)	Chlorophyl A
	Chlorophyl B

Macronutrients

-Ammonia
Nitrite
-Nitrate
Kjeldahl Nitrogen
Ortho Phosphate
-Total Phosphorus

Micronutrients

Boron
-Copper
-Iron
Manganese
-Zinc
Cobalt
Silica

TABLE II-3 (cont.)

<u>Trace Metals</u>	<u>Trace Non-Metals</u>
-Aluminum	-Arsenic
Barium	-Cyanide
Beryllium	MBAS
Bismuth	Phenols
Cadmium	Pesticides
Chromium	Herbicides
Gallium	
Germanium	
-Lead	
-Lithium	<u>Radioactive Constituents</u>
Mercury	Cesium 137
Nickel	-Gross Alpha
Selenium	Gross Beta as Cesium 137
Silver	Gross Beta as Strontium 90
Tin	
Titanium	
Vanadium	
Zirconium	

* Continuous values shown on preceeding hydrographs

- Values plotted on chemographs which follow

TABLE II-4
 APPLICABLE WATER QUALITY STANDARDS
 AND CRITERIA
 (in mg/l unless otherwise noted)

CONSTITUENT	EPA INTERIM DRINKING WATER STANDARDS	NAS WATER QUALITY CRITERIA			UTAH STATE WATER STANDARDS
		PUBLIC WATER SUPPLIES	WILDLIFE AND FRESHWATER AQUATIC LIFE	AGRICULTURE	
Alkalinity			>75 ave ¹⁾		
Dissolved Solids			NC ¹⁾	500-1000	
Hardness					
Non-carbonate					
Hardness					
Oil and Grease		0±	0.05LC ₅₀ ²⁾		
pH (units)			6.5-8.5 ¹⁾	4.5-9.0	6.5-8.5
Specific					
Conductance					
(µmhos/cm)				750-1500	
Temperature			±2°C ¹⁾		
Calcium					
Magnesium					
Potassium					
Sodium					
SAR				1)	
% Sodium					
Strontium					
Bicarbonate					
Carbonate					
Chloride		250			
Sulfate		250			
Sulfide			0.002		
Fluoride		1.4		1)	
Bromide					
Carbon Dioxide					
Dissolved Oxygen			>4		>5.5
BOD					
COD					
SOC					
TOC					
TIC					
DOC					
Total Coliforms					
(Count/100ml)		20000			5000
Fecal Coliforms					
(Count/100ml)		2000		1000	
Chlorophyll A					
Chlorophyll B					
Fecal Strep					

TABLE II-4
 APPLICABLE WATER QUALITY STANDARDS
 AND CRITERIA
 (Cont.)

Ammonia		0.5	0.05LC ₅₀ ²⁾		
Nitrite		1		10	
Nitrate	10	10 1)		100 1)	
Kjeldahl Nitrogen					
Orthophosphate					
Total Phosphorous					
Boron				750	
Copper		1000	0.1LC ₅₀ ²⁾	200	
Iron		300		5000	
Manganese		50		200	
Zinc		5000	0.005LC ₅₀ ²⁾	2000	
Molybdenum				10	
Cobalt				50	
Silica					
Aluminum				5000	
Barium	1000	1000		100	
Beryllium					
Bismuth					
Cadmium	10	10	30	50	
Chromium	50	50	50	1000	
Gallium					
Germanium					
Lead	50	50	30	50	
Lithium				2500	
Mercury	2	2	0.2	10	
Nickel			0.02LC ₅₀ ²⁾	20	
Selenium	10	10		50	
Silver	50				
Tin					
Titanium					
Vanadium					
Zirconium				100	
Arsenic	50	100		200	
Cyanide		200	5 1)		
MBAS		0.5			
Phenols		1	100 1)		
Pesticides	3)	3)	3)		
Herbicides	3)	3)	3)		
Cesium 137					
Gross Alpha (pci/l)	15	5		5 1)	
Gross Beta (pci/l)	8	5		5 1)	
Gross Beta (Cs-137)					

TABLE II-4
APPLICABLE WATER QUALITY STANDARDS
AND CRITERIA
(Cont.)

- 1) Standard is too lengthy to completely summarize in tabular form. See the reference for a comprehensive discussion.
- 2) The notation LC₅₀ means the concentration found to be lethal to 50% of the most sensitive aquatic species native to the study area during a 96 hour exposure.
- 3) Standards are set for individual compounds rather than as a class. The following are the EPA interim drinking water standards.

CONSTITUENT	MAXIMUM PERMISSABLE LEVEL (mg/l)
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
2,4-D	0.1
Silvex	0.01

contact with water. Dissolved solids concentration levels peak during baseflow, when ground water seepage constitutes a major portion of streamflow. Because ground water moves slowly through the soil and rock, allowing longer contact than with surface water, more minerals are dissolved. Concentrations of dissolved solids in streams within the study area are usually highest from August through February.

Historical Water Quality

Historical water quality data for the study area are available from 1951 to the present for Station S-3 on the White River. The historical mean monthly constituent concentrations for samples from Station S-3 are shown on figures II-25 and II-26.

Water Quality: White River

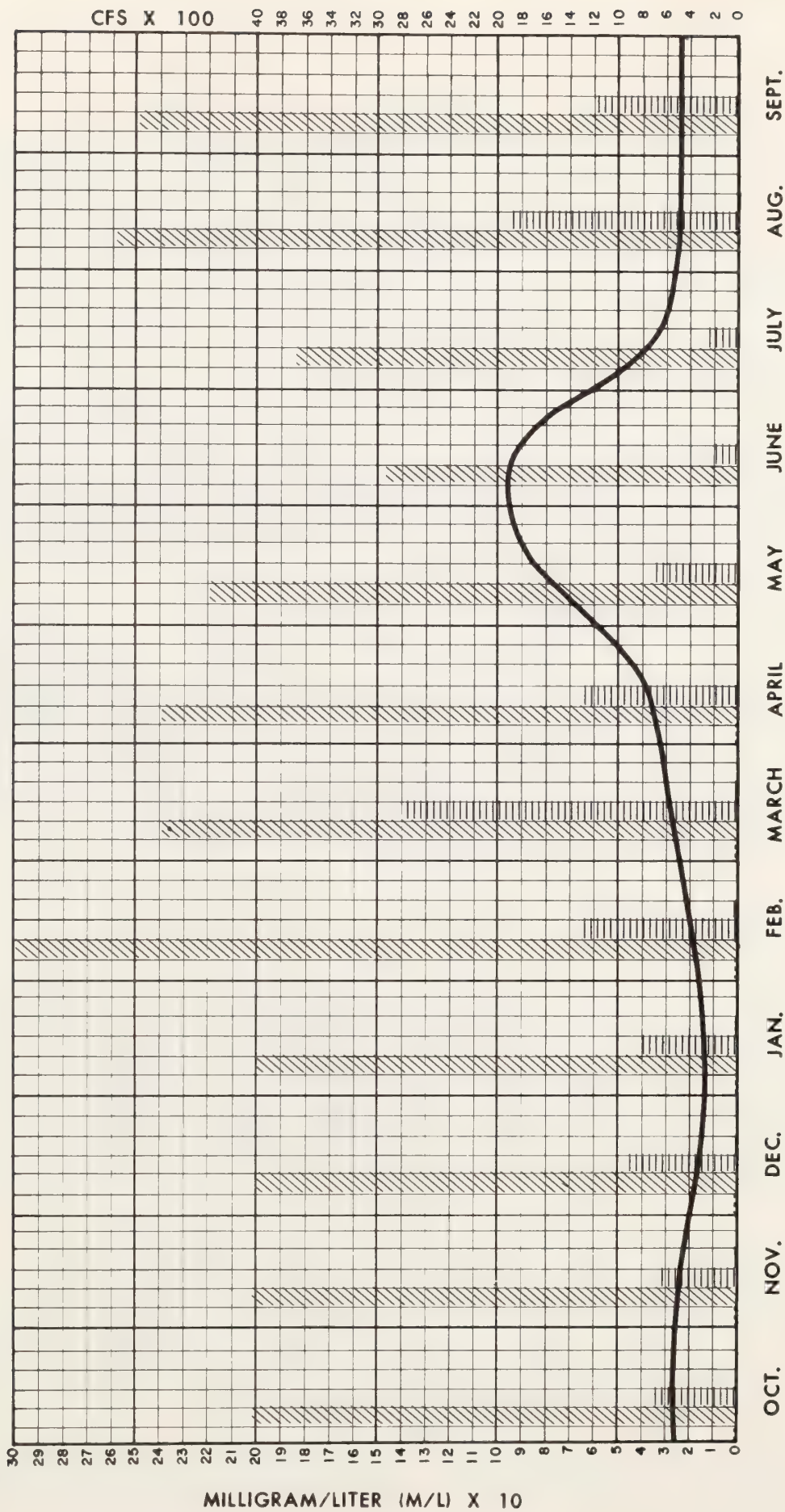
The seasonal variations of general water quality characteristics throughout the study area during the first and second years of monitoring are shown on figures II-27 and II-28, respectively. The monitoring stations during the second year--stations S-1, S-3, and S-11--are the same as those used during the first year, with the exception of Station S-4, which was deleted in early July of the second year of monitoring.

General Characteristics

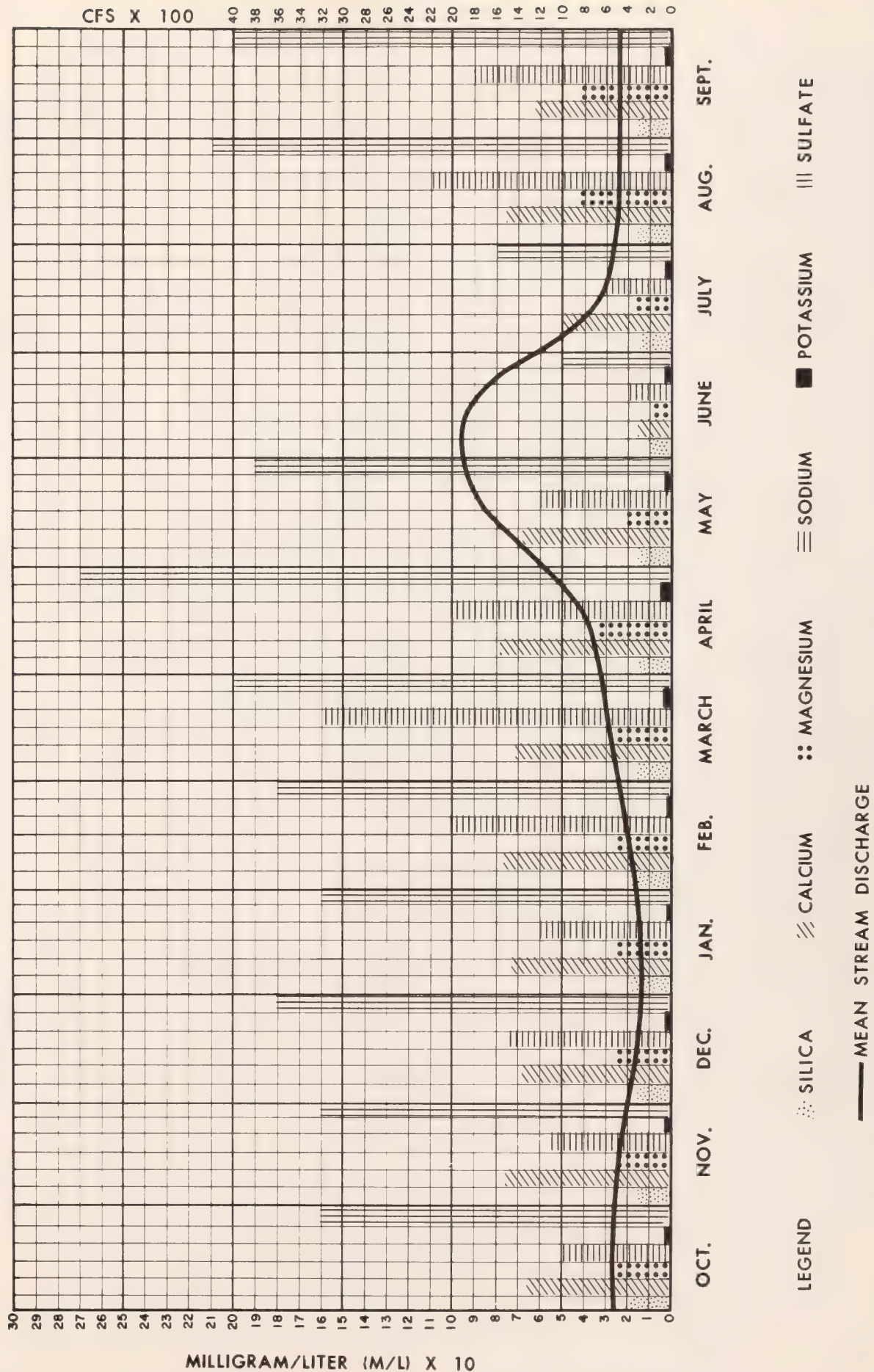
The three general characteristics shown on figures II-27 and II-28 are dissolved solids, suspended sediment, and pH. The time scale used is identical to that used in the previous year's hydrographs for easy comparison of streamflow and water quality. The major difference in comparing chemographs for the two years is the frequency of sampling for chemical analysis, which dropped from twice monthly during the first year to monthly during the second year.

Dissolved solids in the White River were highest during low streamflow and decreased with increasing streamflow, as was typical of the first year of monitoring. Dissolved solids reached the lowest concentration in June and July during peak flow, increased rapidly during August, remained fairly stable through the winter and early spring months during baseflow, and peaked in April during lower basin runoff.

While dissolved solids generally vary inversely with streamflow, suspended sediment concentrations vary directly with streamflow. Suspended sediment levels increased gradually from January through

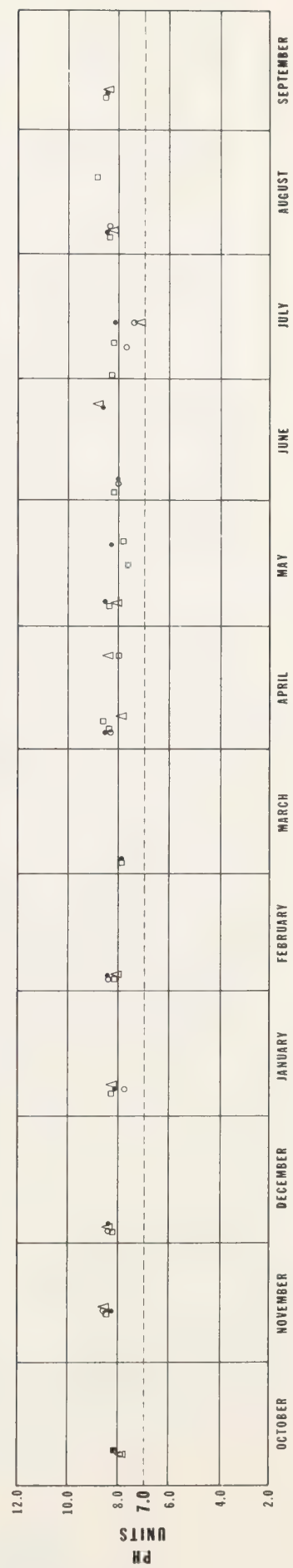
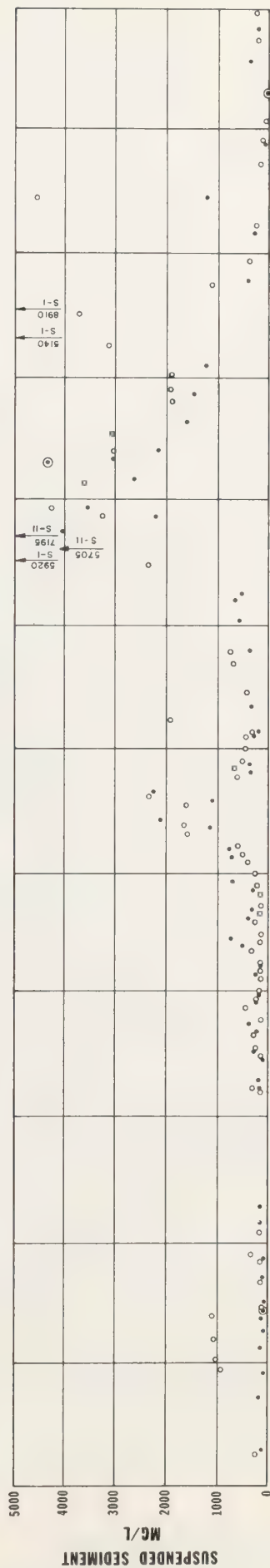
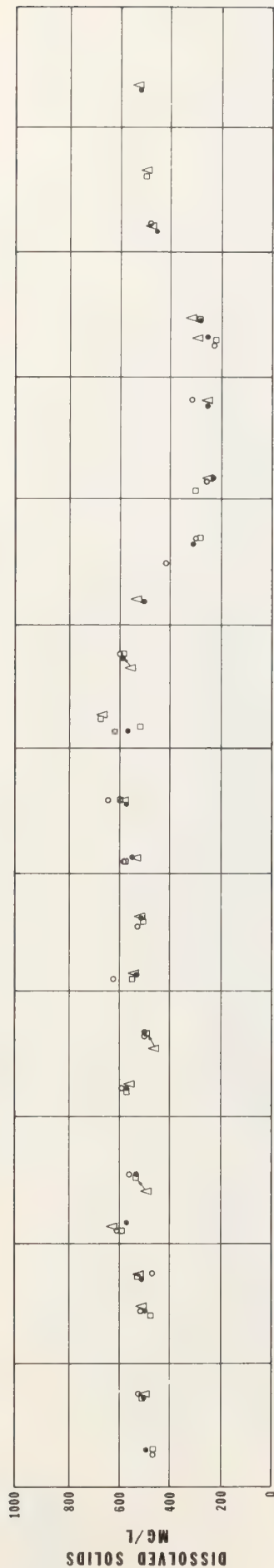


GENERAL WATER QUALITY
WHITE RIVER : WATSON (9-6500)



GENERAL WATER QUALITY
WHITE RIVER : WATSON (9-6500)



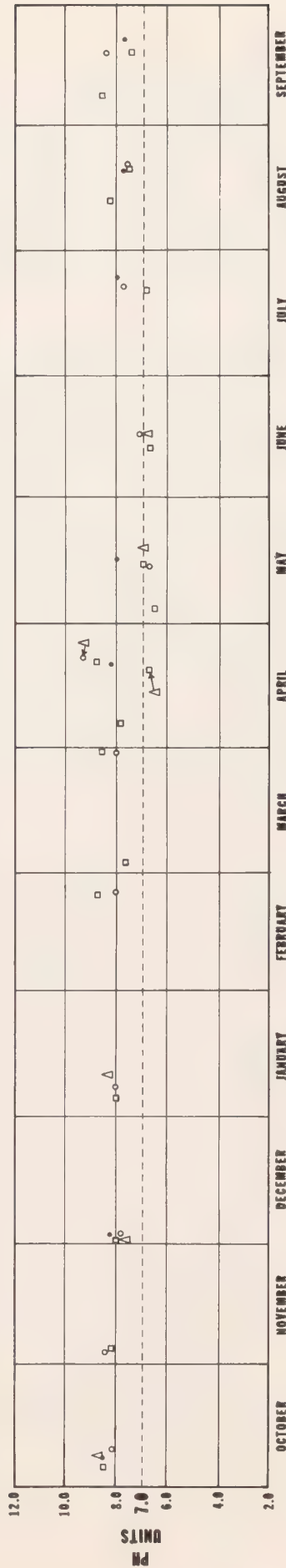
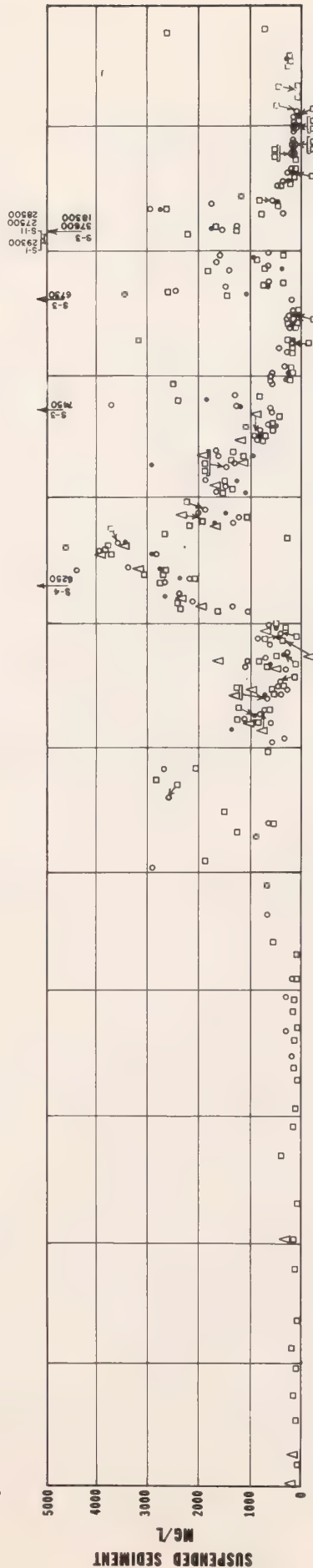
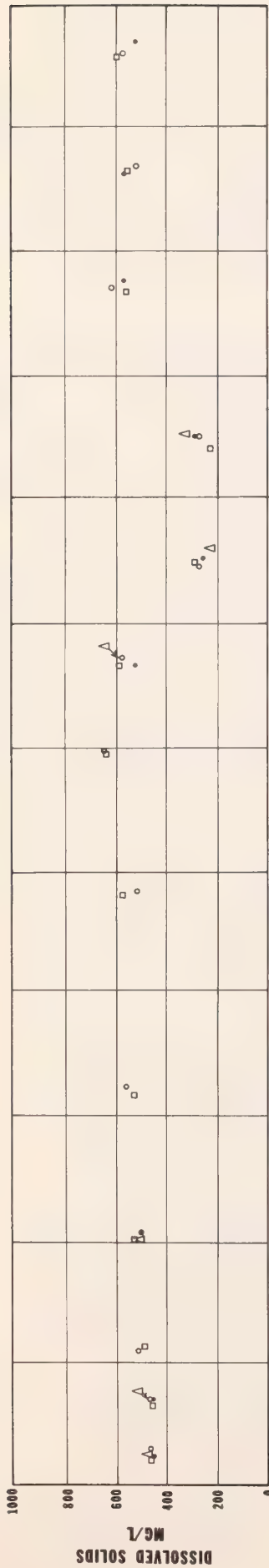


LEGEND

- WHITE RIVER ABOVE HELLS HOLE CANYON (S-1)
- WHITE RIVER NEAR WATSON (S-3)
- △ WHITE RIVER ABOVE SOUTHAM CANYON (S-4)
- WHITE RIVER BELOW ASPHALT WASH (S-11)

VARIATION OF GENERAL CHARACTERISTICS
 WHITE RIVER FROM ABOVE HELLS HOLE CANYON TO BELOW ASPHALT WASH
 OCTOBER 1974 - SEPTEMBER 1975





LEGEND

- WHITE RIVER ABOVE HELLS HOLE CANYON (S-1)
- WHITE RIVER NEAR WATSON (S-3)
- △ WHITE RIVER ABOVE SOUTHWAM CANYON (S-4)
- WHITE RIVER BELOW ASPHALT WASH (S-11)

VARIATION OF GENERAL CHARACTERISTICS

WHITE RIVER FROM ABOVE HELLS HOLE CANYON TO BELOW ASPHALT WASH
OCTOBER 1975 - SEPTEMBER 1976

FIGURE II-28



March, rose rapidly in April, peaked in May and then declined in August. Minimum levels were reached in September and remained at approximately the same levels in October through December, coinciding with the period of baseflow (August through January). Occasional high sediment concentrations were recorded for certain stations during March and June through August, reflecting the high variability of suspended sediment in response to side channel inflows caused by intense local thunderstorms. For this reason sediment levels may fluctuate widely between stations depending on localized conditions.

In contrast to the other two general characteristics, pH levels did not fluctuate markedly with streamflow or between stations, remaining slightly above 8.0 throughout both years. This slightly alkaline condition is typical of streams in the western United States and falls within the accepted range of 6.0 to 9.0, which is considered suitable for all uses (NAS 1972).

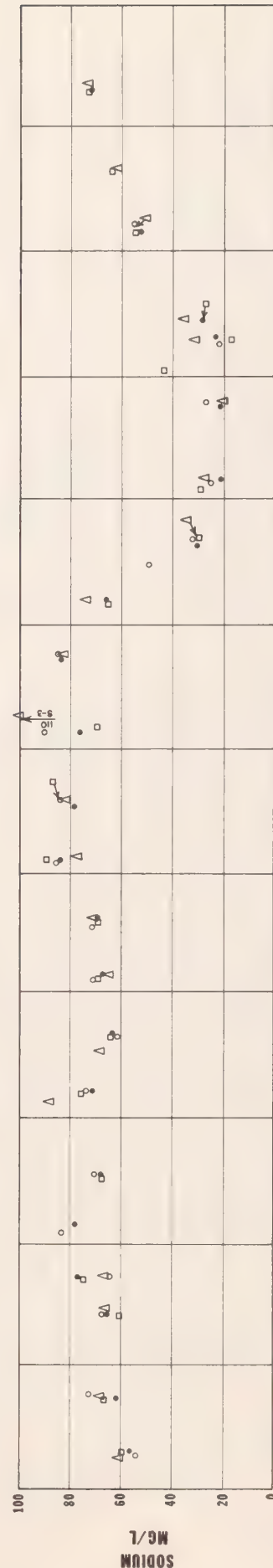
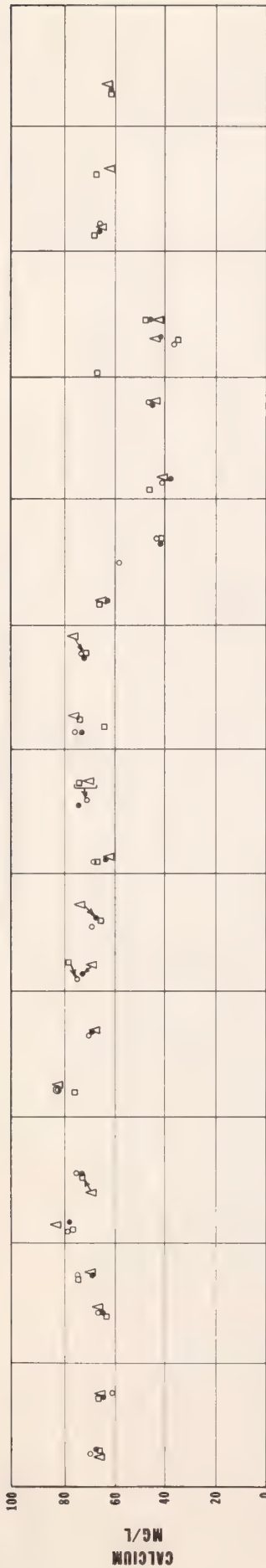
Major Dissolved Elements--Cations: The dominant cations (positively charged ions) found in the White River are calcium, magnesium, and sodium (figures II-29 and II-30). Potassium is present in concentrations usually below 10 mg/l. These elements, to a degree, reflect overall streamflow patterns and showed little difference in concentrations between stations across the study area (refer to II.A.2.c., Interpretation and Conclusions). The major difference in the general pattern during the second year was the shorter duration of peak flow, which was confined to May and June and was reflected by more rapid fluctuations in the concentration levels of the affected cations.

As during the first year of monitoring, concentrations of calcium generally ranged between 60 mg/l and 80 mg/l during baseflow. However, peak readings in 1976 occurred in January, July and August, compared to peaks in December, January and April in 1975. These changes are attributed to annual variations in streamflow patterns.

Magnesium concentrations followed a similar pattern, although at lower levels. Concentration values were between 20 mg/l and 40 mg/l during baseflow, peaked during the months immediately preceding and following highflow, and dropped to the 10 mg/l level during May and June.

Sodium concentrations exhibited the greatest fluctuation in response to changes in streamflow, indicating more sensitivity to changes in the ratio between surface runoff and ground water. Sodium concentrations ranged from 55 mg/l to 95 mg/l during baseflow (a slightly wider range than during the preceding year) and 15 mg/l to 30 mg/l during highflow.

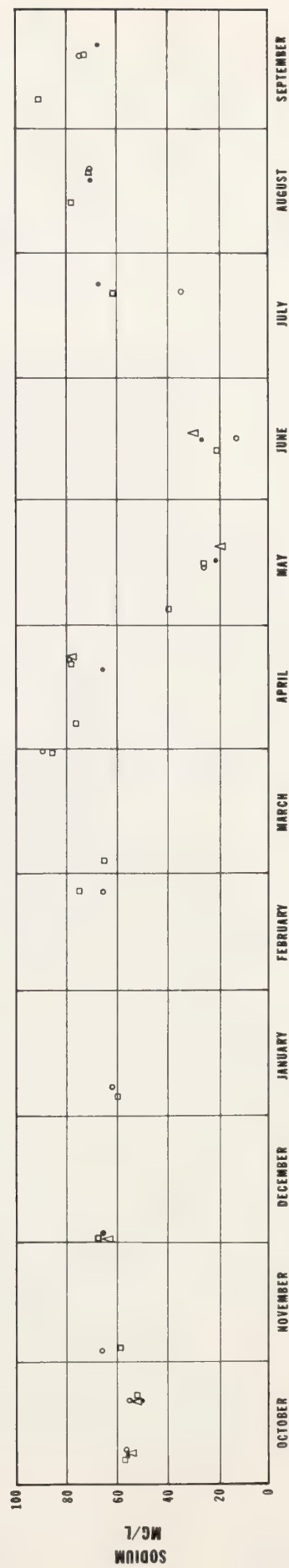
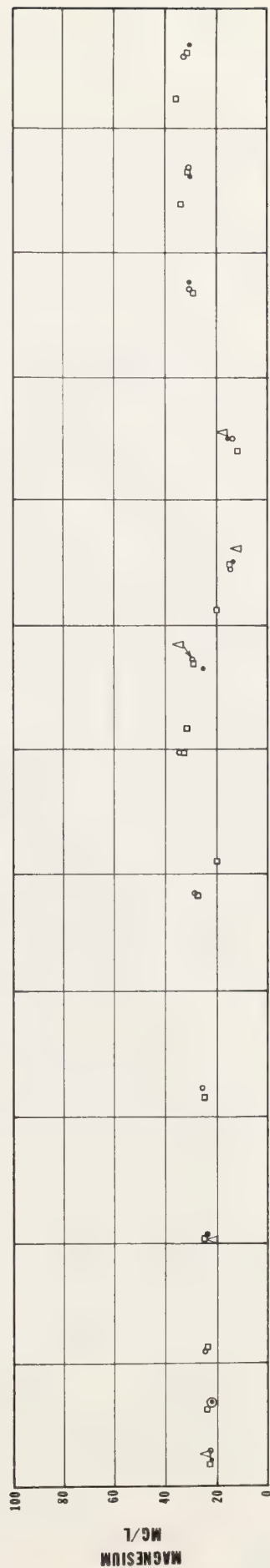
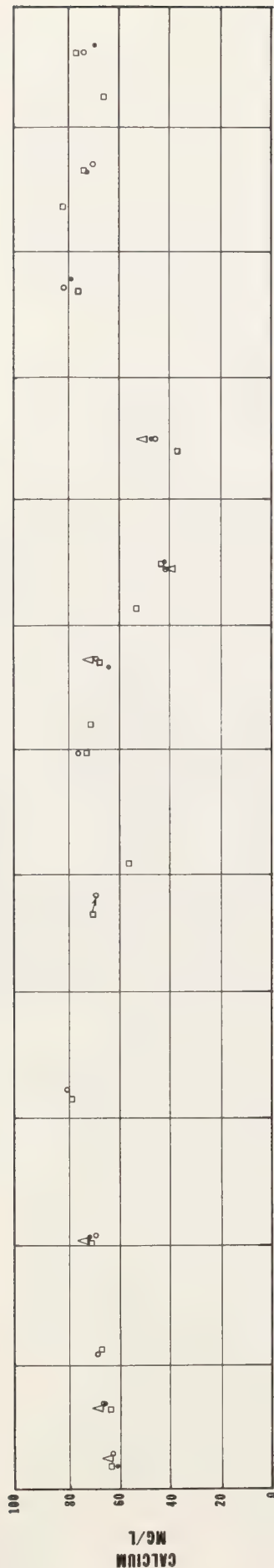
Potassium displayed a parallel pattern to the other elements, with maximum concentrations of around 6 mg/l during baseflow and 5 mg/l during highflow.



LEGEND
 ● WHITE RIVER ABOVE HELLS HOLE CANYON (S-1)
 □ WHITE RIVER NEAR WATSON (S-3)
 △ WHITE RIVER ABOVE SOUTHAM CANYON (S-4)
 ○ WHITE RIVER BELOW ASPHALT WASH (S-11)

VARIATION IN TIME OF MAJOR CATIONS
 WHITE RIVER FROM ABOVE HELLS HOLE CANYON TO BELOW ASPHALT WASH
 OCTOBER 1974 - SEPTEMBER 1975





LEGEND

- WHITE RIVER ABOVE HELLS HOLE CANYON (S-1)
- WHITE RIVER NEAR WATSON (S-3)
- △ WHITE RIVER ABOVE SOUTHAM CANYON (S-4)
- WHITE RIVER BELOW ASPHALT WASH (S-11)

VARIATION IN TIME OF MAJOR CATIONS

WHITE RIVER FROM ABOVE HELLS HOLE CANYON TO BELOW ASPALT WASH
OCTOBER 1975 - SEPTEMBER 1976



Major Dissolved Elements--Anions: The major anions (negatively-charged ions) found in the White River are bicarbonate, sulfate, and chloride (figures II-31 and II-32), along with much smaller amounts of fluoride, bromide, sulfide, nitrate, and phosphate.

Bicarbonate ion concentrations remained relatively constant through both years of monitoring, with a slight reduction in values during upper basin snowmelt. Concentration levels ranged between 150 mg/l and 300 mg/l throughout the monitoring program, except during upper basin runoff (May through July 1975; May through June 1976), when concentrations declined to slightly below 150 mg/l.

Bicarbonate concentrations are closely related to pH values and alkalinity. Because carbonic acid is not present in water with a pH over 9.0 and bicarbonate most typically occurs within a pH range of 7.0 to 9.0, bicarbonate ions are dominate in the White River, which has a pH of around 8.0. Alkalinity is closely related to the presence of bicarbonate ions, and alkalinity levels were correspondingly consistent throughout the monitoring program, averaging between approximately 140 mg/l and 240 mg/l during the second year.

Sulfate concentrations in the White River averaged approximately the same during both years, about 180 mg/l during baseflow and about 80 mg/l during highflow. The second year of data exhibited a slightly lower range, however, with highest values in April of approximately 240 mg/l compared to about 260 mg/l the preceding year.

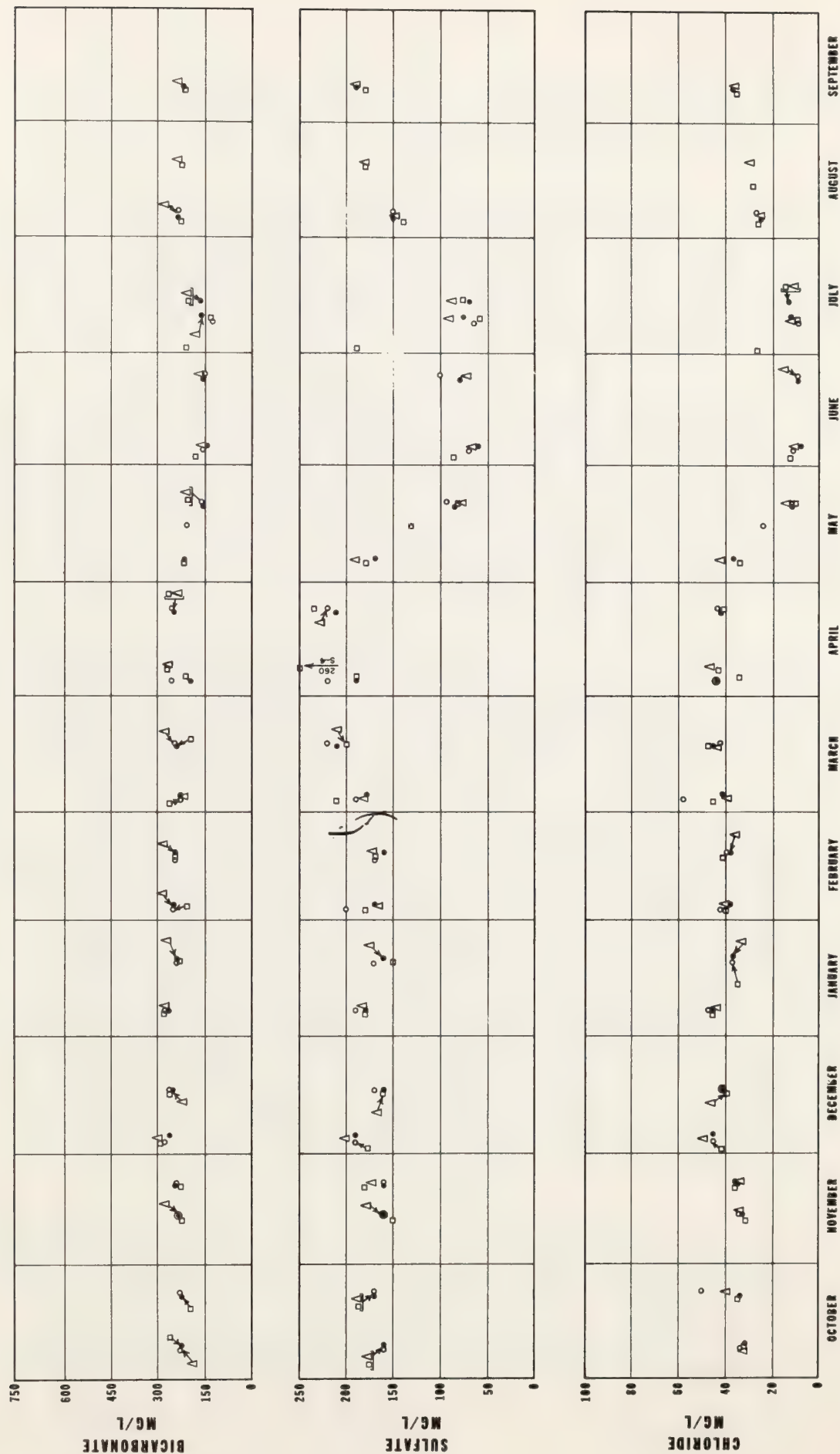
Little variation occurred in chloride concentration levels between the first and second year of monitoring, with the exception of slightly higher values during July through September of the second year. Otherwise, concentrations remained close to 40 mg/l during baseflow and dropped to between 10 mg/l and 20 mg/l during highflow (May and June). These levels are well within recommended concentrations for irrigation purposes. Fluoride levels remained almost constant during the first year, ranging from an average of 0.3 mg/l during baseflow to 0.2 mg/l during highflow, which is well within quality standards for irrigation, livestock and potable uses. There was little variation in bromide levels, which averaged 0.2 mg/l during baseflow, 0.1 during lower basin runoff, and 0.03 during upper basin runoff.

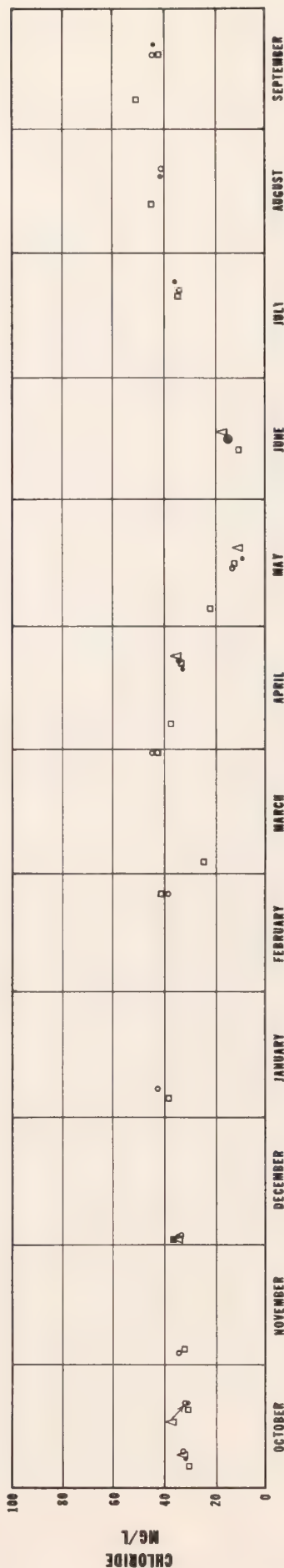
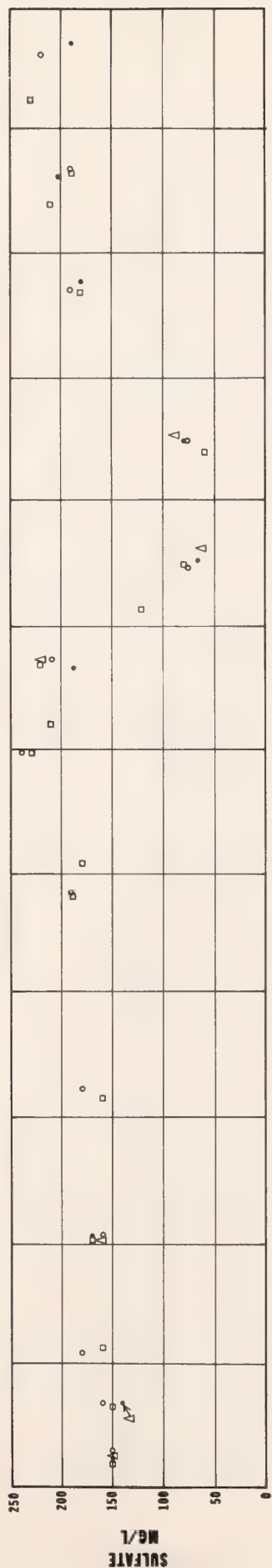
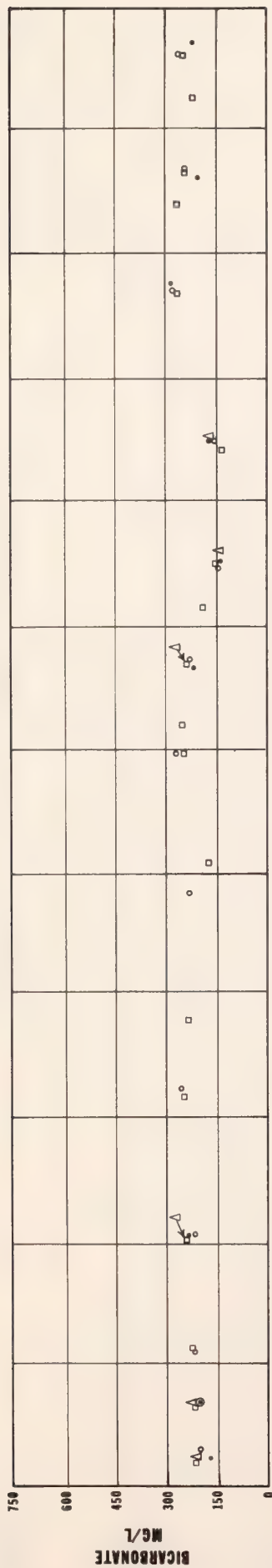
Biochemical Constituents: Dissolved oxygen levels ranged between 8 mg/l and 12 mg/l during baseflow, declining to between 6 mg/l and 9 mg/l during upper basin runoff (figers II-33 and II-34.

Chemical oxygen demand remained low (below 15 mg/l) throughout the year, increasing only slightly to around 25 mg/l during upper



VARIATION IN TIME OF MAJOR ANIONS
WHITE RIVER FROM ABOVE BELLS HOLE CANYON TO BELOW ASPHALT WASH
OCTOBER 1974 - SEPTEMBER 1975





LEGEND

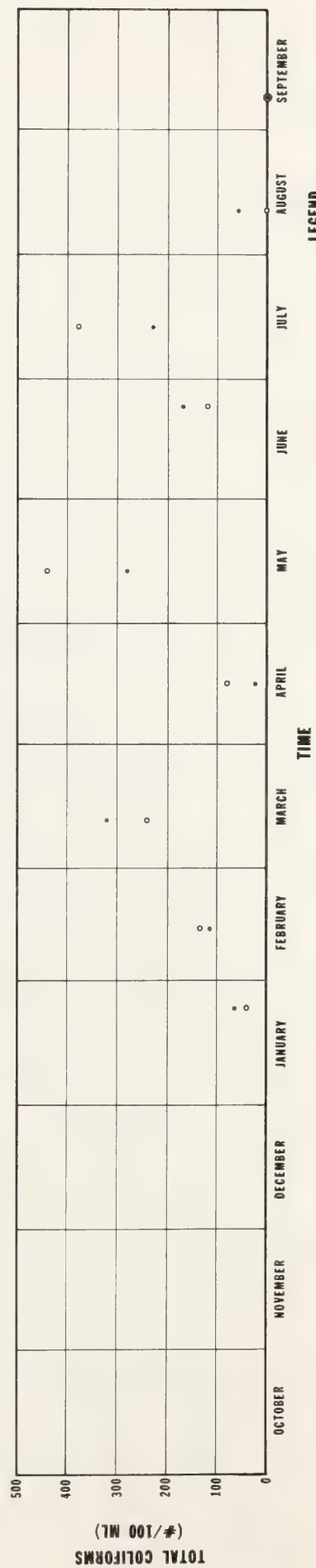
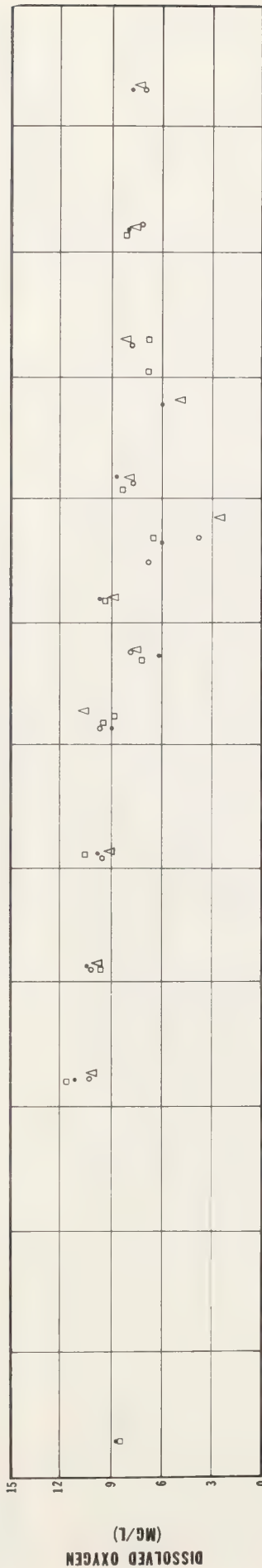
- WHITE RIVER ABOVE WELLS HOLE CANYON (S-1)
- WHITE RIVER NEAR WATSON (S-3)
- △ WHITE RIVER ABOVE SOUTHAM CANYON (S-4)
- WHITE RIVER ABOVE SOUTHAM CANYON (S-4)
- WHITE RIVER BELOW ASPHALT WASH (S-11)

FIGURE II-32

VARIATION IN TIME OF MAJOR ANIONS

WHITE RIVER FROM ABOVE WELLS HOLE CANYON TO BELOW ASPHALT WASH
OCTOBER 1975 - SEPTEMBER 1976





LEGEND

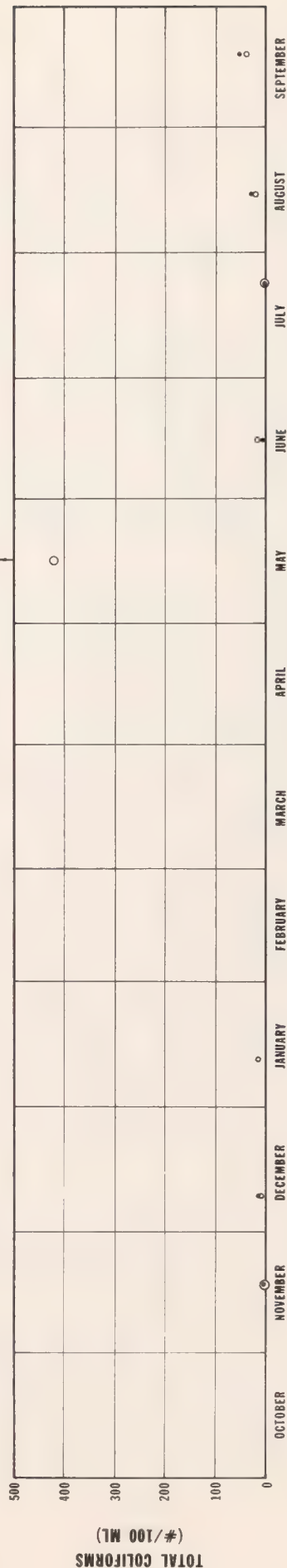
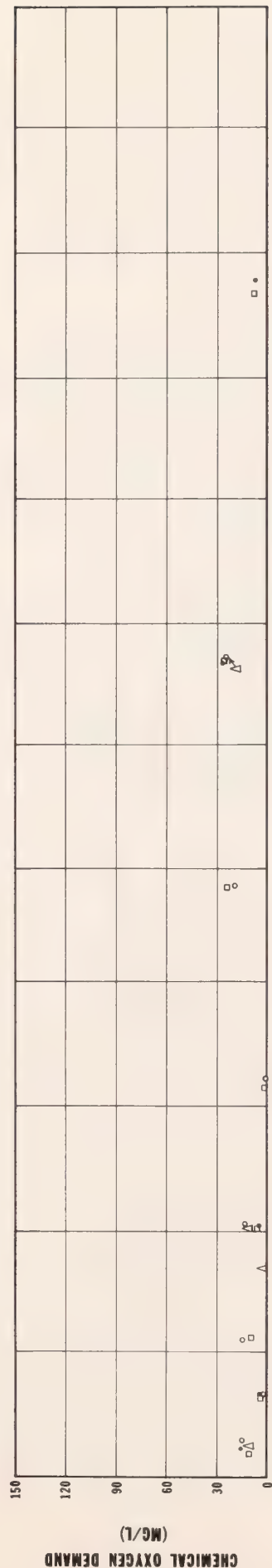
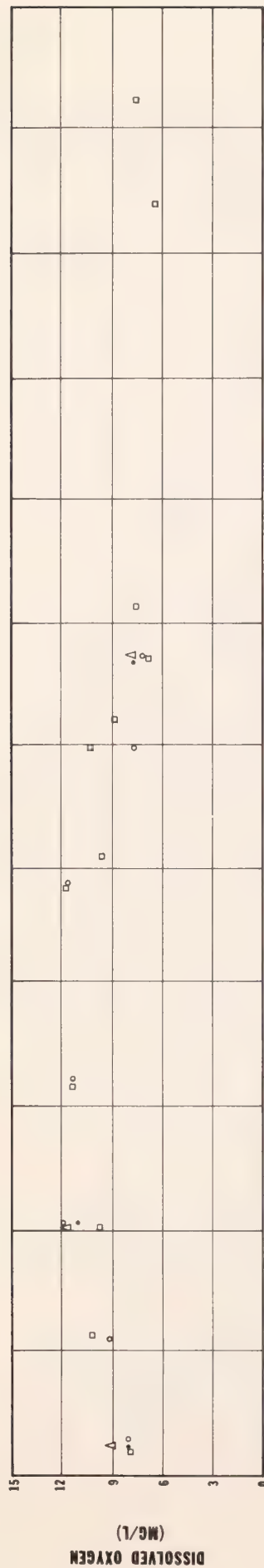
- WHITE RIVER ABOVE HELLS HOLE CANYON (S-1)
- WHITE RIVER NEAR WATSON (S-3)
- △ WHITE RIVER ABOVE SOUTHAM CANYON (S-4)
- WHITE RIVER BELOW ASPHALT WASH (S-11)

VARIATION IN TIME OF BIOCHEMICAL CONSTITUENTS

WHITE RIVER FROM ABOVE HELLS HOLE CANYON TO BELOW ASPHALT WASH

OCTOBER 1974 - SEPTEMBER 1975

FIGURE II-33



LEGEND

- WHITE RIVER ABOVE HELLS HOLE CANYON (S-1)
- WHITE RIVER NEAR WATSON (S-3)
- △ WHITE RIVER ABOVE SOUTHAM CANYON (S-4)
- WHITE RIVER BELOW ASPHALT WASH (S-11)

FIGURE II-:

VARIATION IN TIME OF BIOCHEMICAL CONSTITUENTS

WHITE RIVER FROM ABOVE HELLS HOLE CANYON TO BELOW ASPHALT WASH

OCTOBER 1975 - SEPTEMBER 1976



basin runoff.

Total coliform levels were significantly lower during the second year of monitoring, with values below 10/100 ml during most of the year. Peak values were around 50/100 ml in September. Both total coliform and fecal coliform levels were well below Utah water quality standards of 5000/100 ml and 2000/100 ml monthly averages, respectively, during both years of monitoring.

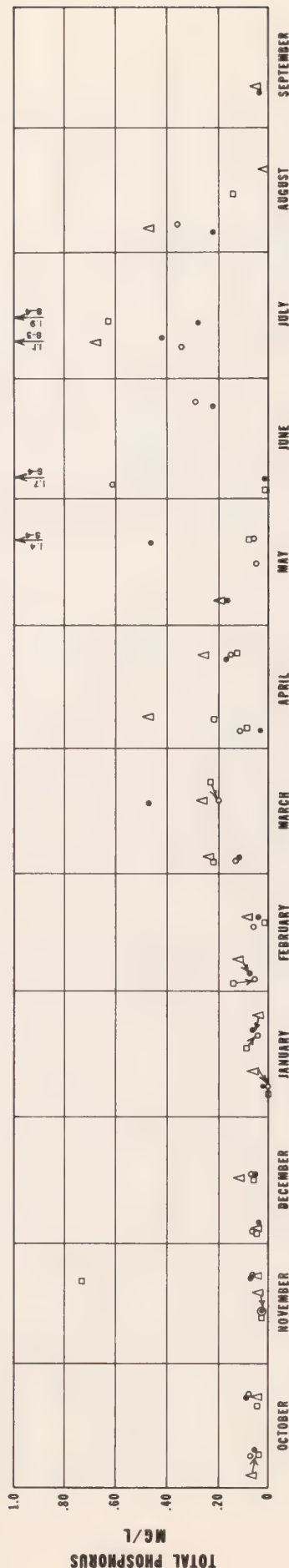
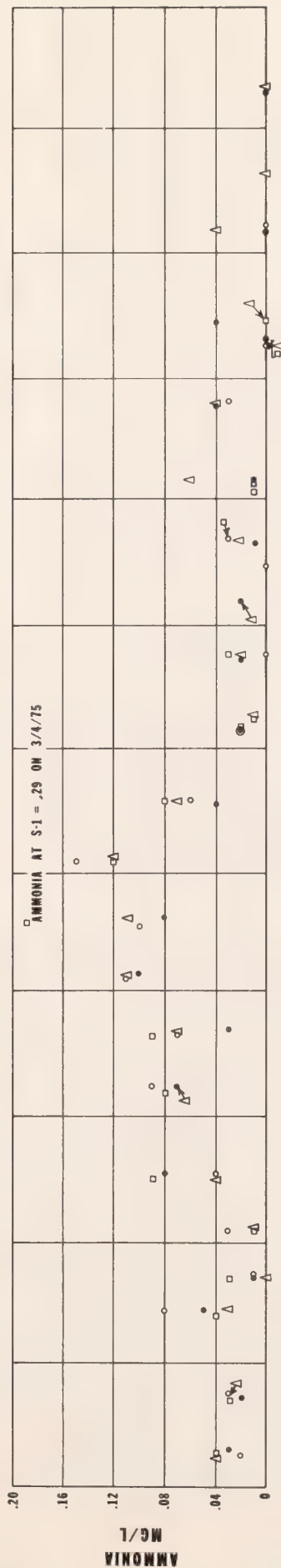
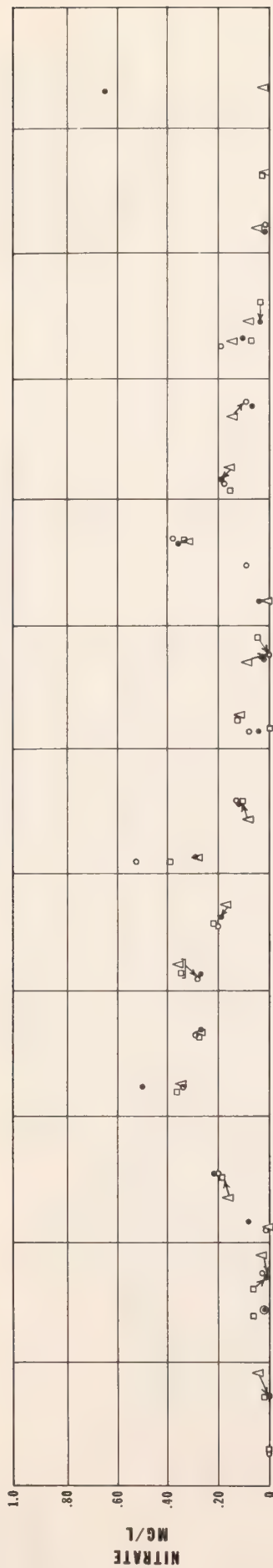
Mean fecal strep concentrations were slightly lower (26/100 ml as compared to 30/100 ml) during the second baseflow period (August 1975 to January 1976) although exhibiting a wider range, but increased significantly (to 269/100 ml) during the final baseflow period (July to September 1976). No comparison of lower basin runoff levels can be made because of the lack of second-year data. Fecal strep concentrations were generally lower during upper basin snowmelt than levels recorded for the previous year.

Macronutrients: Concentrations of nitrate, ammonia, and phosphorus, the major nutrients of importance in controlling aquatic life, are shown on figures II-35 and II-36. Nitrate levels were highest, between 0.3 mg/l and 0.4 mg/l, during February and May 1976. Nitrate levels reflect nutrient use by aquatic microorganisms, which are in turn controlled by light and temperature. Consequently, nitrate levels are highest during winter, when the growth of aquatic life is inhibited, and during peak flow, when light penetration is reduced by increased sediment loads.

Ammonia is influenced by the same controls as nitrate, but temperature is a more dominant factor. As a result, ammonia levels peak only in December and January, with no second peak during upper basin runoff, because the water is sufficiently warm to support the oxidation of ammonia, even though the light penetration is insufficient to stimulate nitrate use. Total Kjeldahl nitrogen concentrations, which include ammonia and organic nitrogen, varied directly with the flow cycle during both years of monitoring, probably reflecting the effect of undecayed organic matter washed into the river by surface runoff.

Phosphorus concentrations corresponded directly with stream-flow, with levels remaining around 10 mg/l during baseflow (August through January) and increasing to between 50 mg/l and 65 mg/l in May 1976.

Chlorophyll A and Chlorophyll B, which closely follow nitrate levels, showed little change from the first year of monitoring, ranging from a minimum of 0.00 mg/l for both constituents to a maximum of 13.0 mg/l to 15.0 mg/l, respectively, for both years.



LEGEND

- WHITE RIVER ABOVE HELLS HOLE CANYON (S-1)
- WHITE RIVER NEAR WATSON (S-3)
- △ WHITE RIVER ABOVE SOUTHMAN CANYON (S-4)
- WHITE RIVER BELOW ASPHALT WASH (S-11)

VARIATION IN TIME OF REPRESENTATIVE MACRONUTRIENTS

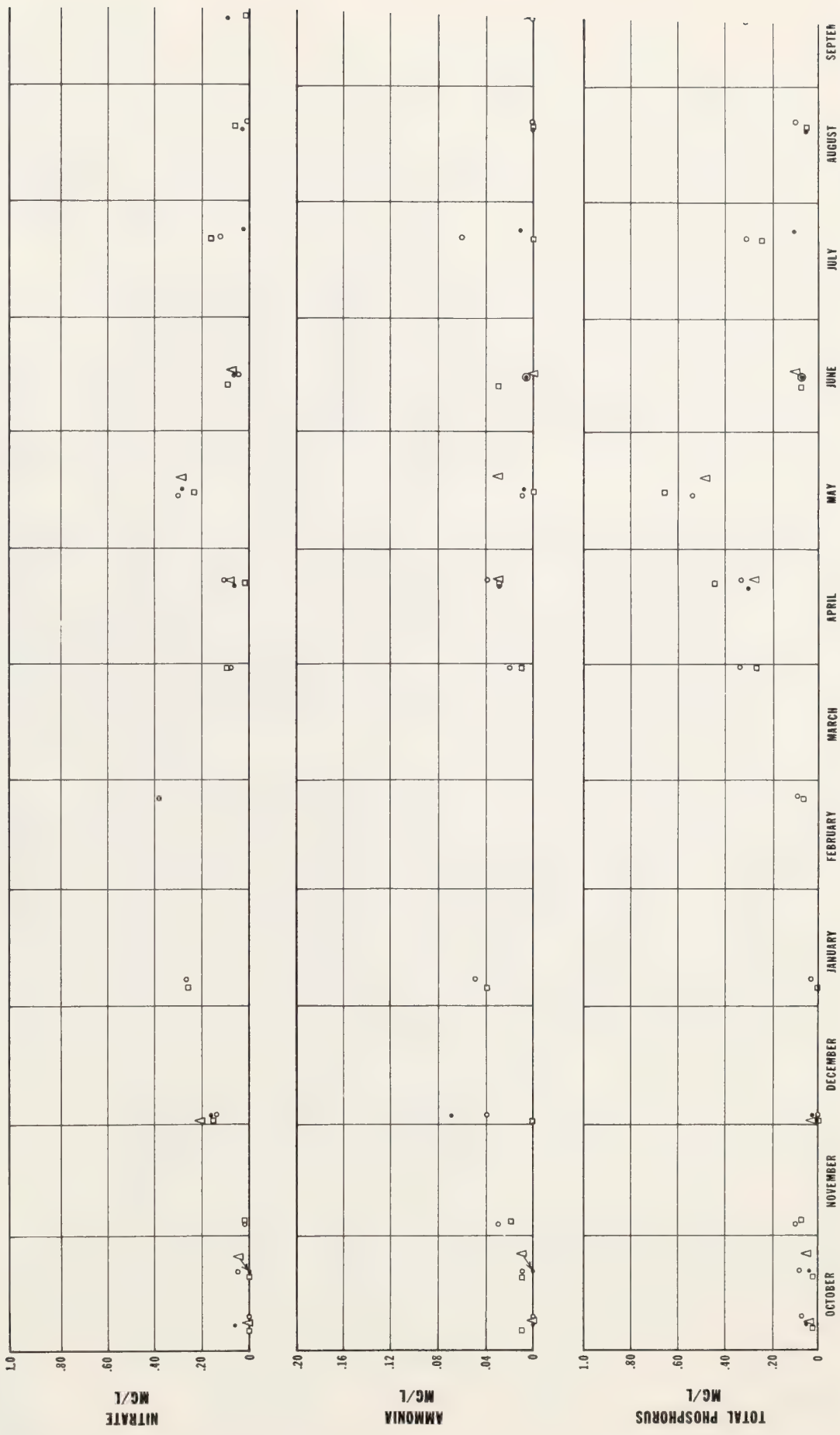
WHITE RIVER FROM ABOVE HELLS HOLE CANYON TO BELOW ASPHALT WASH
OCTOBER 1974 - SEPTEMBER 1975

FIGURE II-35





VARIATION IN TIME OF REPRESENTATIVE MACRONUTRIENTS
WHITE RIVER FROM ABOVE HELLS HOLE CANYON TO BELOW ASPHALT WASH
OCTOBER 1975 - SEPTEMBER 1976

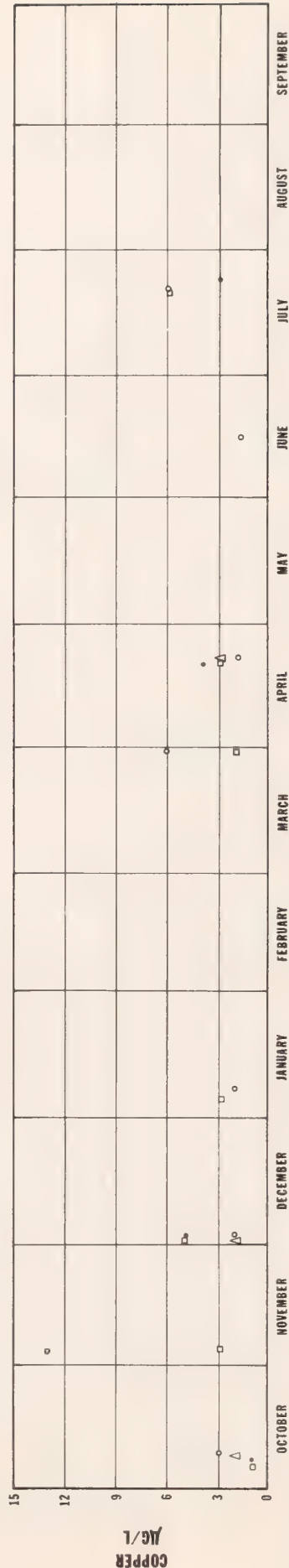
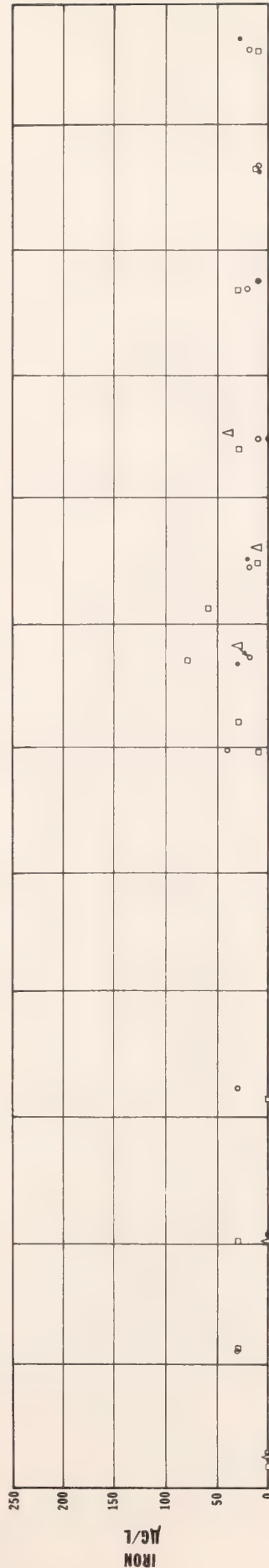
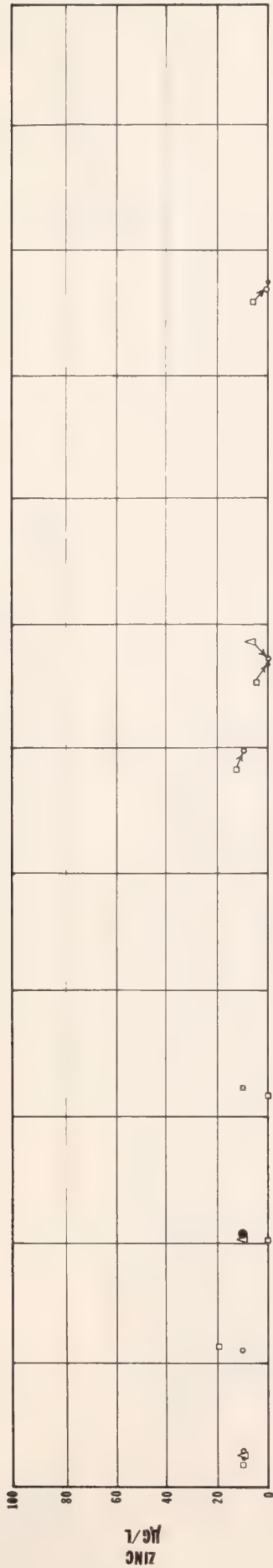


Micronutrients: Micronutrients were discussed in Trace Elements in the FYEBR. This group of constituents includes zinc, iron, copper, boron, manganese, molybdenum, cobalt, and silica. Concentration levels of zinc, iron, and copper in the White River are shown on figures II-37 and II-38.

As during the preceding year, both zinc and copper concentration levels varied with streamflow; zinc concentrations decreased slightly from baseflow to highflow, and iron concentrations showed a light increase. Zinc levels were generally lower during the second year of monitoring, not exceeding 20 µg/l, while iron concentrations remained below 50 µg/l (probably saturated at this dissolved oxygen and pH level) except during peak flow, which was generally consistent throughout the year and during some months varied between stations. Highest values were recorded during November (13 µg/l), December (6 µg/l), March (20 µg/l), April (4 µg/l) and July (6 µg/l), a pattern similar to the preceding year.

The other micronutrients (boron, manganese, cobalt, silica and molybdenum) generally varied only slightly between the first and second year of monitoring. The mean levels of manganese and silica for both years decreased to 4 µg/l and 13 µg/l, respectively, during baseflow and to 9 µg/l and 12 µg/l during lower basin runoff. The mean cobalt levels increased from a high of 1 µg/l in 1975 to a high of <11 µg/l in 1976. There was a decrease in boron levels during baseflow (<100 µg/l in 1975 to 83 µg/l in 1976) and an increase in molybdenum concentrations from 3 µg/l in 1975 to 32 µg/l in 1976 during lower basin runoff.

Trace Metals: Baseflow values remained approximately the same for most metals, although compared with the preceding year mean values of aluminum (19 µg/l to 26 µg/l), barium (67 µg/l to 125 µg/l), chromium (5 µg/l to <10 µg/l), and vanadium (1.8 µg/l to 2.8 µg/l) increased, and lead (2 µg/l to 1 µg/l), nickel (5 µg/l to 3 µg/l), and tin (<6 µg/l to <5 µg/l) decreased. During 1976 lower basin runoff several elements occurred at lower levels including aluminum (33 µg/l to 28 µg/l), barium (52 µg/l to 33 µg/l), and lithium (30 µg/l to 14 µg/l) (figures II-39 and II-40). Elements with higher levels recorded in 1976 included lead (1 µg/l to 10 µg/l), nickel (2 µg/l to 3 µg/l) and vanadium (1.3 µg/l to 1.7 µg/l). Measurements of the remaining trace metals during lower basin runoff were below the detection limits during both years. There were few changes during upper basin runoff, although a number of elements occurred at higher levels including aluminum, barium, beryllium, bismuth, gallium, germanium, lead, nickel, tin, vanadium, and zirconium. Only lithium decreased, while the other elements remained essentially at 1975 levels. There were few changes during upper basin snowmelt, although aluminum declined slightly from levels recorded during the previous year (35 µg/l to 24 µg/l).



LEGEND

- WHITE RIVER ABOVE HELLS HOLE CANYON (S-1)
- WHITE RIVER NEAR WATSON (S-3)
- △ WHITE RIVER ABOVE SOUTHMAN CANYON (S-4)
- WHITE RIVER BELOW ASPHALT WASH (S-11)

VARIATION IN TIME OF SOME MICRONUTRIENTS WHITE RIVER FROM ABOVE HELLS HOLE CANYON TO BELOW ASPHALT WASH OCTOBER 1975 - SEPTEMBER 1976

FIGURE II-38



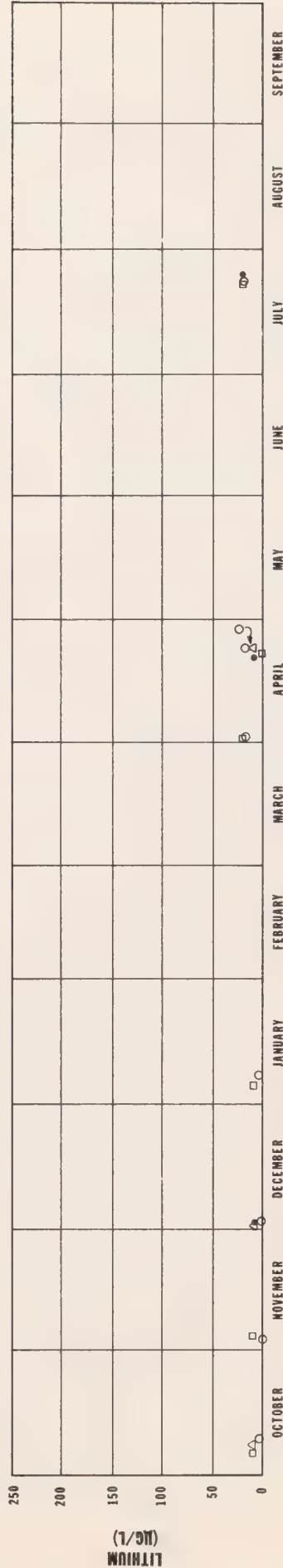
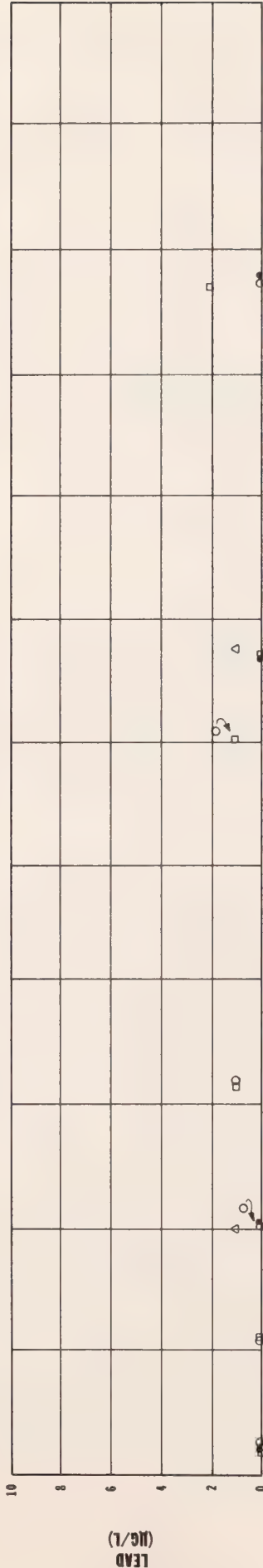
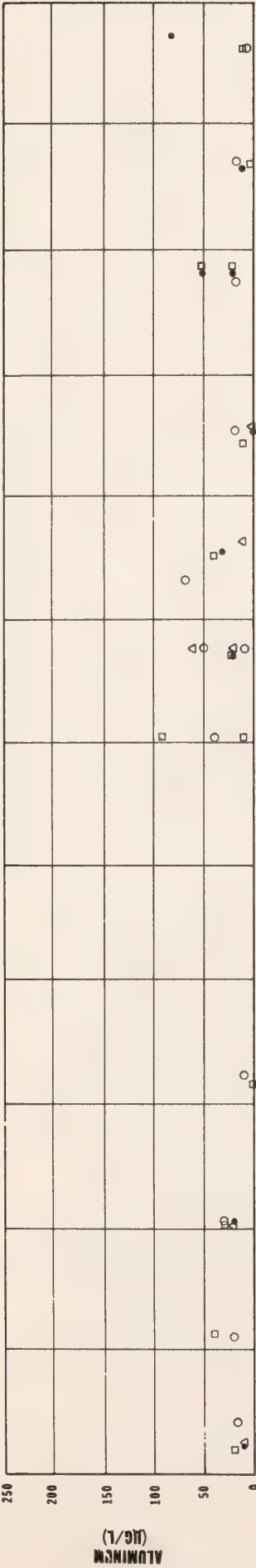


LEGEND

- WHITE RIVER ABOVE HELLS HOLE CANYON (S-1)
- WHITE RIVER NEAR WATSON (S-3)
- △ WHITE RIVER ABOVE SOUTHAM CANYON (S-6)
- WHITE RIVER BELOW ASPHALT WASH (S-11)

VARIATION IN TIME OF SOME TRACE METALS
 WHITE RIVER FROM ABOVE HELLS HOLE CANYON TO BELOW ASPHALT WASH
 OCTOBER 1974 - SEPTEMBER 1975





LEGEND

- WHITE RIVER ABOVE HELLS HOLE CANYON (S-1)
- WHITE RIVER NEAR WATSON (S-3)
- △ WHITE RIVER ABOVE SOUTHAM CANYON (S-4)
- WHITE RIVER BELOW ASPHALT WASH (S-11)

VARIATION IN TIME OF SOME TRACE METALS
WHITE RIVER FROM HELLS HOLE CANYON TO BELOW ASPHALT WASH

OCTOBER 1975 - SEPTEMBER 1976

FIGURE II-40



Trace Non-Metals: Most trace non-metals remained at or near the levels reported during the previous year. Arsenic levels were slightly lower during baseflow (1 $\mu\text{g/l}$ in 1975 compared to 0.5 $\mu\text{g/l}$ in 1976) and higher during lower basin runoff, and phenols increased (3 $\mu\text{g/l}$ to 4 $\mu\text{g/l}$) during baseflow and decreased (5 $\mu\text{g/l}$ to 3 $\mu\text{g/l}$) during lower basin runoff in comparison with figures from the previous year (figures II-41 and II-42).

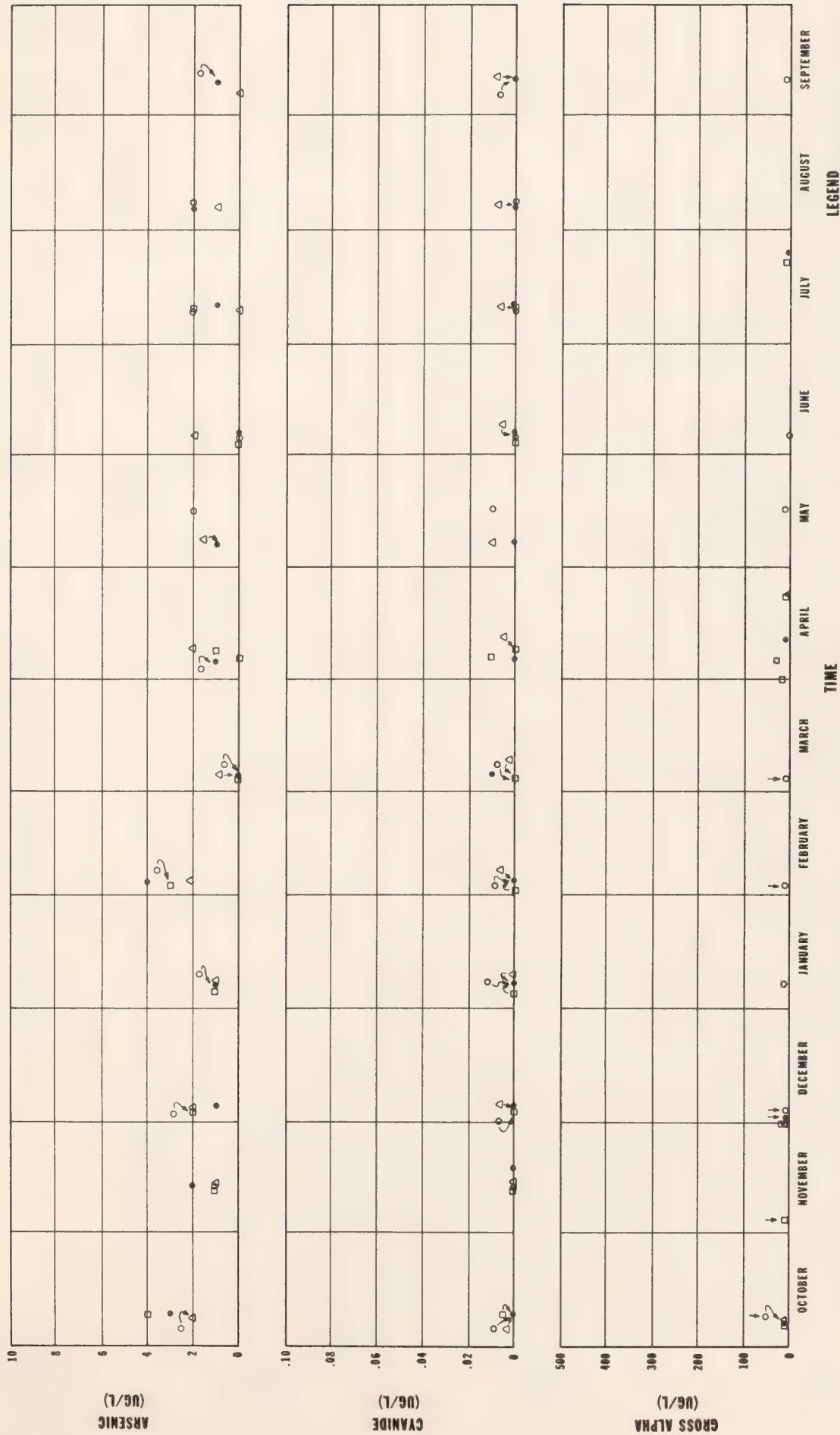
Radioactive Constituents: Gross alpha was recorded at 9.7 $\mu\text{g/l}$ in 1975 and at 9.3 $\mu\text{g/l}$ in 1976 during baseflow, and 15.6 $\mu\text{g/l}$ and 12.6 $\mu\text{g/l}$ during lower basin runoff. Gross beta as cesium 137 was recorded at 5.2 pc/l in 1975 and 6.1 pc/l in 1976 during baseflow and 5.4 pc/l and 8.0 pc/l during lower basin runoff. Gross beta as strontium 90 was recorded at 5.5 pc/l and 5.0 pc/l during baseflow and at 5.0 pc/l and 4.0 pc/l during lower basin runoff. Cesium 137 remained at consistently low levels (around 1.0 pc/l) during both years.

Water Quality: Evacuation Creek

Water quality analyses for Evacuation Creek encompassed the same parameters as those described for the White River. During the second year of monitoring, sampling continued at Station S-6, upstream south of the study area, and Station S-2, near the mouth of the stream; sampling was suspended at Station S-7 in December 1975. As in the case of the White River, sampling frequency was reduced to a monthly schedule during the second year of the program.

General Characteristics: Dissolved solids concentrations continued to be much higher in Evacuation Creek than in the White River, ranging between 3600 mg/l and 4800 mg/l throughout most of the second year, decreasing slightly during April and May. Concentration levels remained about 1000 mg/l higher at Station S-6 than at S-2, except during highflow, because of the stream interface with the bird's nest aquifer between these two stations (see figures II-43 and II-44). During April and May the levels became more uniform because of the greater volume of water flowing between the two stations.

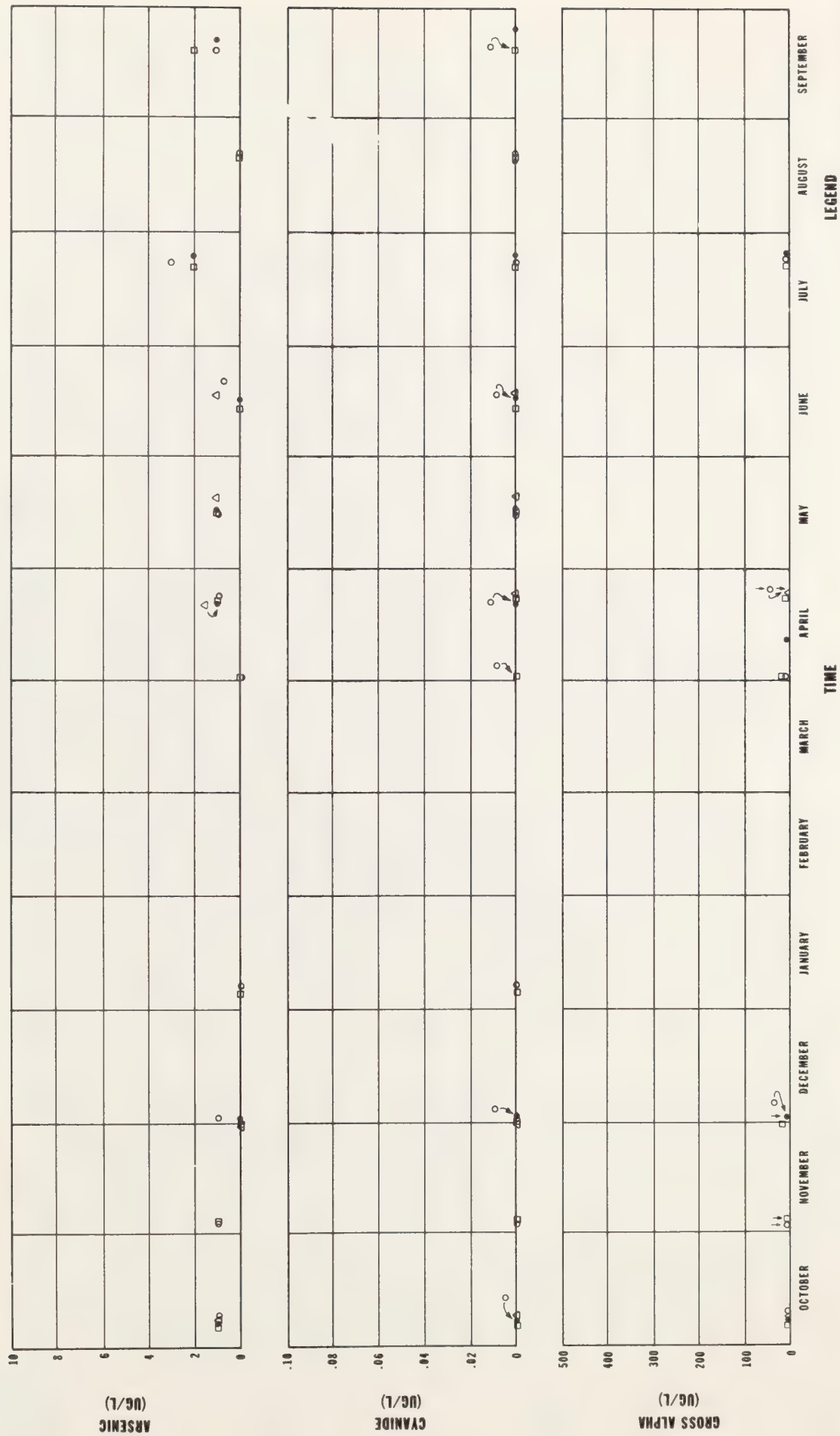
Suspended sediment levels fluctuated widely throughout the second year, with several readings well above 5000 mg/l. Although similar high values also occurred during the first year, the magnitude and distribution of peak values varied between the two years. Highest values occurred at Station S-6 during May 1975 (94,500 mg/l) versus July 1976 (175,000 mg/l), reflecting differences in highflow occurrence. Values were higher than in 1975 during March, April, and July, but considerably lower in May. The relationship between baseflow and highflow values remained fairly constant, however, with values below 1000 mg/l from June 1975 through January 1976 (as compared to July through



VARIATIONS WITH TIME OF SEVERAL TRACE NON-METALS INCLUDING RADIOACTIVE CONSTITUENTS
 WHITE RIVER FROM HELLS HOLE CANYON TO BELOW ASPHALT WASH
 OCTOBER 1974 - SEPTEMBER 1975

FIGURE II-41





LEGEND

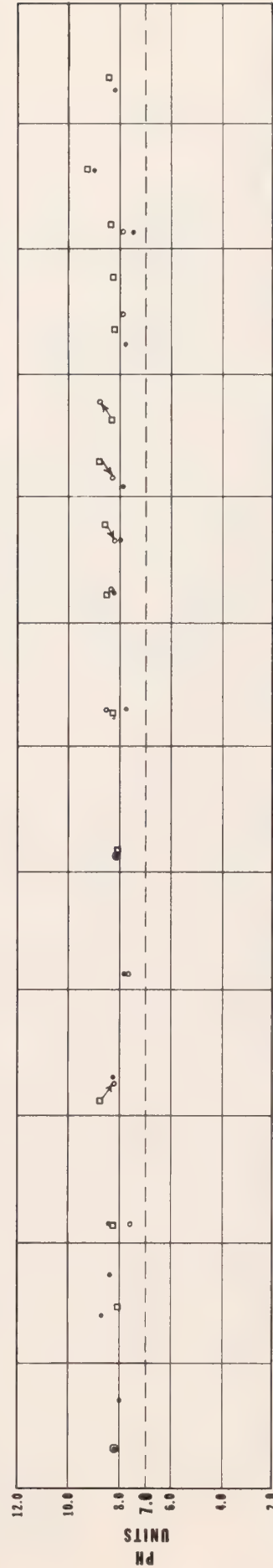
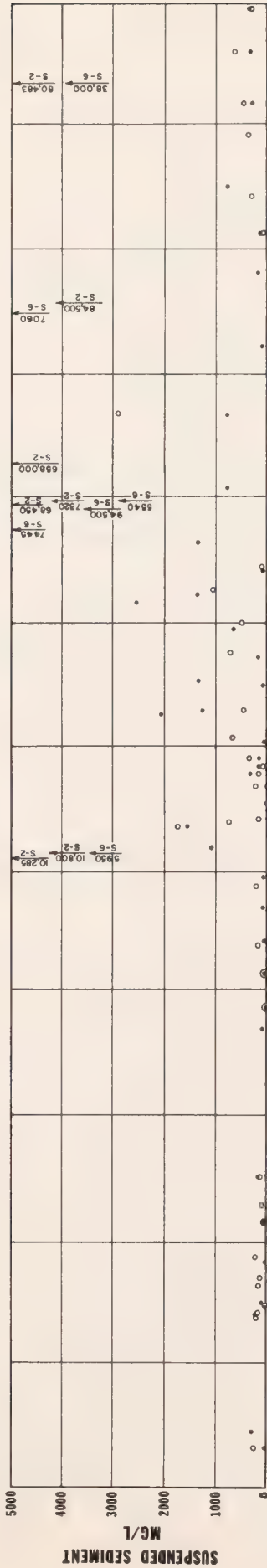
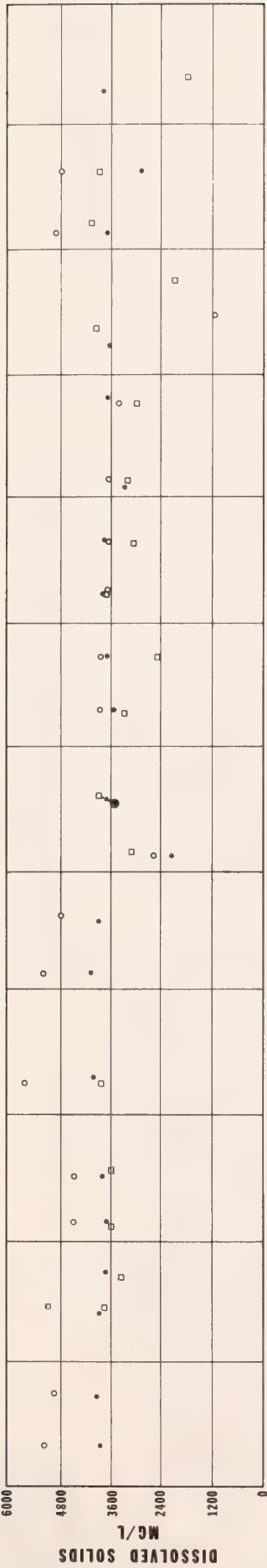
- WHITE RIVER ABOVE HELLS HOLE CANYON (S-1)
- WHITE RIVER NEAR WATSON (S-3)
- △ WHITE RIVER ABOVE SOUTHAM CANYON (S-4)
- WHITE RIVER BELOW ASPHALT WASH (S-11)

VARIATIONS WITH TIME OF SEVERAL TRACE NON-METALS INCLUDING RADIOACTIVE CONSTITUENTS

WHITE RIVER FROM HELLS HOLE CANYON TO BELOW ASPHALT WASH

OCTOBER 1975 - SEPTEMBER 1976





LEGEND

- EVACUATION CREEK BELOW PARK CANYON, UTAH (S-7)
- EVACUATION CREEK AT WATSON, UTAH (S-6)
- EVACUATION CREEK NEAR MOUTH (S-2)

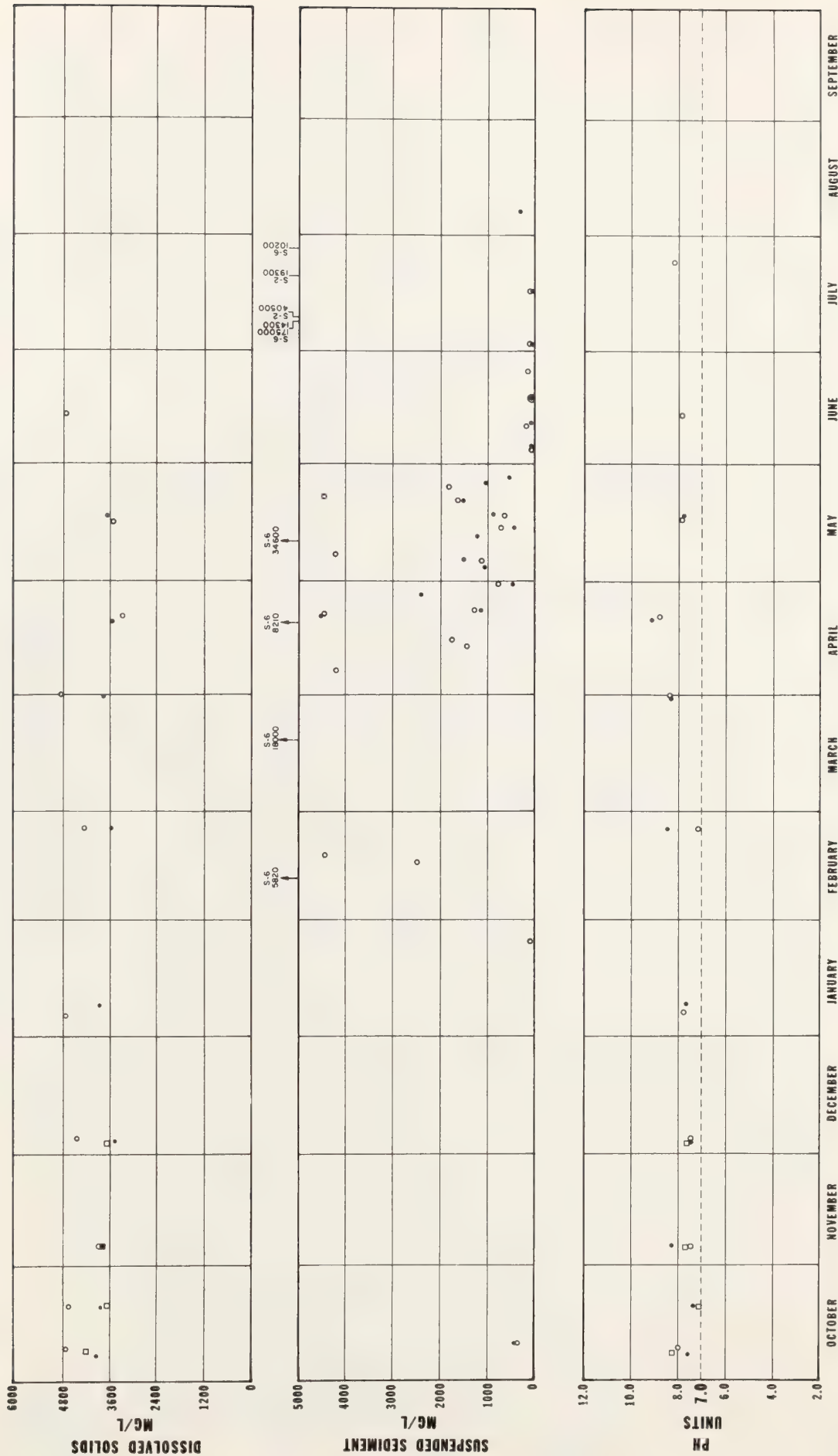
VARIATION OF GENERAL CHARACTERISTICS

EVACUATION CREEK FROM BELOW PARK CANYON TO MOUTH

OCTOBER 1974 - SEPTEMBER 1975

FIGURE II-43





VARIATION OF GENERAL CHARACTERISTICS

EVACUATION CREEK FROM BELOW PARK CANYON TO MOUTH

OCTOBER 1975 - SEPTEMBER 1976

LEGEND

- EVACUATION CREEK BELOW PARK CANYON (S-7)
- EVACUATION CREEK AT WATSON, UTAH (S-6)
- EVACUATION CREEK NEAR MOUTH (S-2)

FIGURE II-44



February 1975) increasing sharply from February to May 1976 (as compared to March through June 1975).

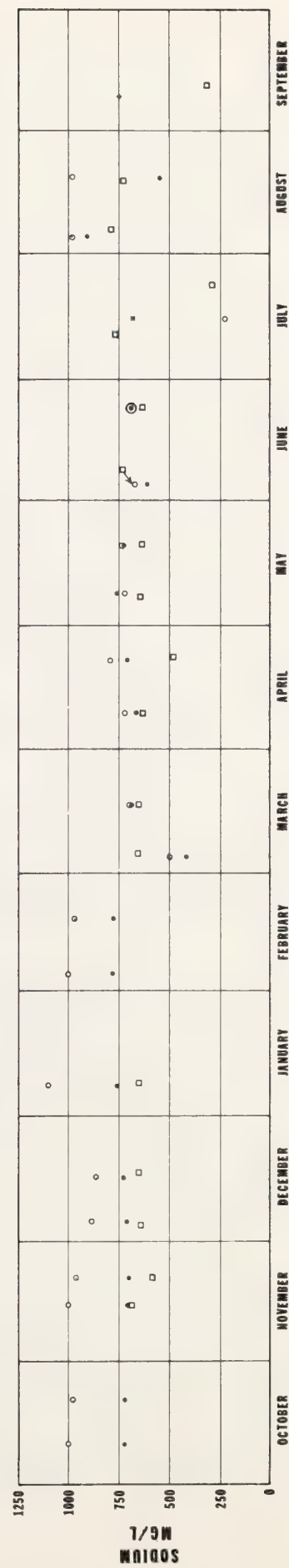
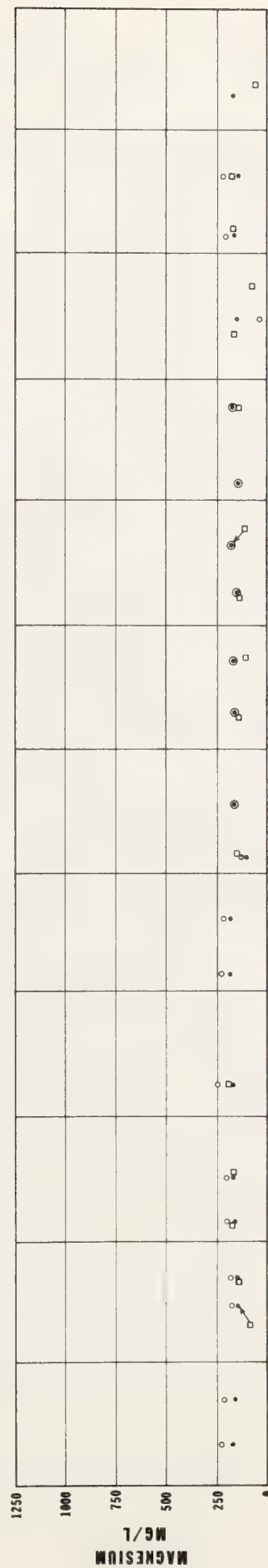
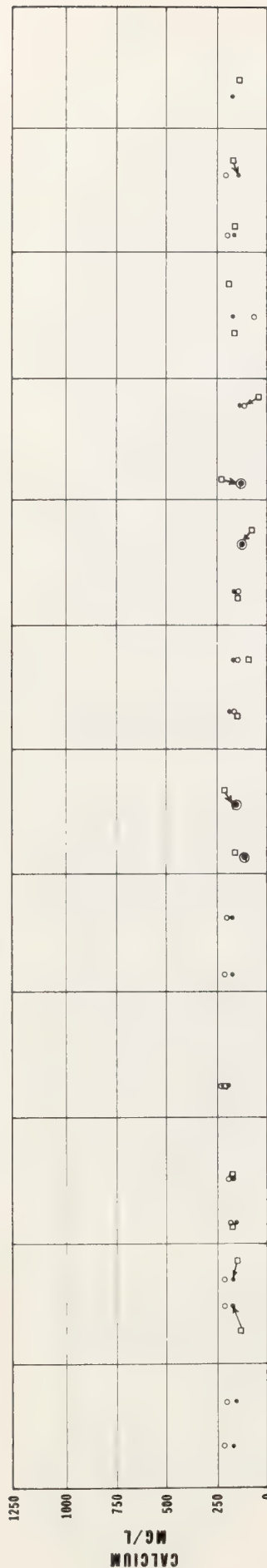
The water in Evacuation Creek exhibited slightly lower pH during the second year falling generally below 8.0 from October 1975 to January 1976 and in May and June 1976. During the previous year most values were slightly above 8.0 indicating that the water became less alkaline. The mean values of alkalinity for both years combined fluctuated between stations S-7 (384 mg/l), S-6 (450 mg/l), and S-2 (381 mg/l) during baseflow but showed a slight reversal during highflow with slightly lower mean values at Station S-6 (357 mg/l) than S-2 (373 mg/l). Hardness showed little variation between years during baseflow and highflow periods, with the exception of lower minimum values in 1975 at both stations S-2 (260 mg/l) and S-6 (210 mg/l) during baseflow. Non-carbonate hardness fluctuated moving downstream during baseflow, (692 mg/l at S-7, 835 mg/l at S-6, and 674 mg/l at S-2) but showed a very slight increase during highflow (from 657 mg/l at S-6 to 662 mg/l at S-2). Low levels of oil and grease were reported at stations S-6 and S-7 during baseflow (mean levels of 2.0 mg/l at both stations) and at all stations during highflow (mean levels of 6.0 mg/l at S-6 and 2.1 mg/l at S-2); the only station reporting any significant concentrations was Station S-2 with a maximum of 250 mg/l during baseflow in 1975. Streamflow, temperature, and specific conductance are discussed in "Surface Hydrology, Evacuation Creek."

Major Cations: As shown on figures II-45 and II-46, calcium and magnesium concentrations were nearly identical to levels recorded in 1975, falling within the 100 mg/l to 250 mg/l range throughout the year. Sodium also exhibited a similar pattern to 1975, but with fewer low values (below 500 mg/l) reported.

Potassium levels varied only slightly between stations throughout 1976, although minimum values were lower during highflow (4.6 mg/l at S-6 and 5.8 mg/l at S-2). Sodium absorption ratio (SAR) and percent sodium also remained fairly constant with SAR reaching a maximum of 12.0 and a minimum of 4.5 during 1976. Percent sodium fluctuated between 42 and 62 in 1976. Mean strontium levels were similar for baseflow and highflow (ranging between 3800 µg/l and 3400 µg/l), although maximum and minimum concentration levels fluctuated from 5000 µg/l to 2400 µg/l between the two periods.

Major Anions: Bicarbonate levels were slightly higher (around 580 mg/l) in June and July 1976 at Station S-6, and displayed a narrower range of readings during those two months and March (540 mg/l); otherwise, there was little variation between the two years of monitoring (see figures II-47 and II-48).

Sulfate concentrations generally ranged between 2,000 mg/l and 3000 mg/l in contrast to the previous year, when concentrations



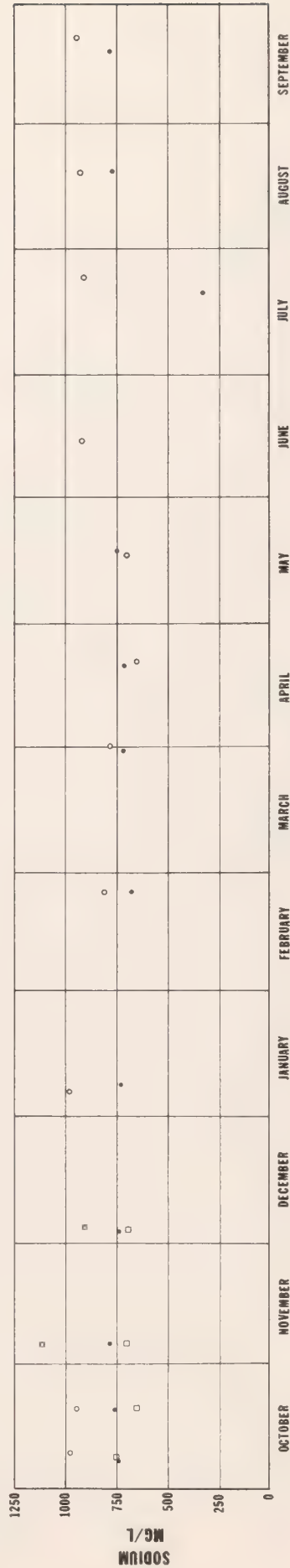
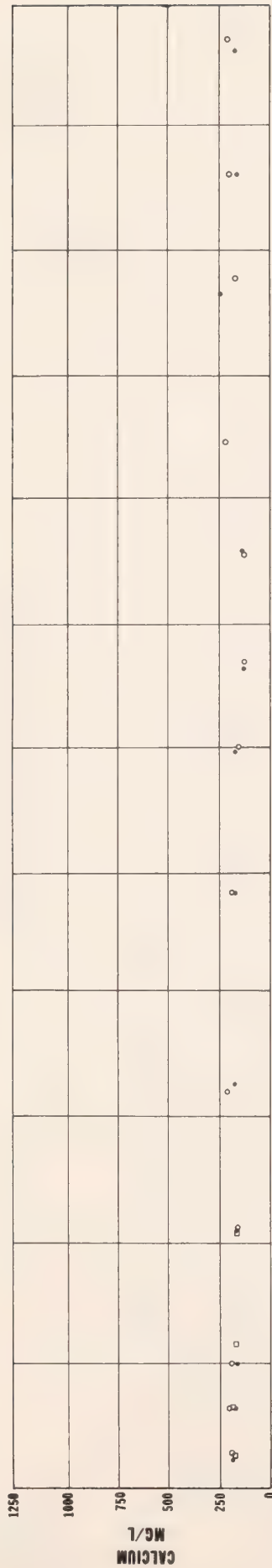
LEGEND

- EVACUACION CREEK BELOW PARK CANYON, UTAH (S-7)
- EVACUACION CREEK AT WATSON, UTAH (S-6)
- EVACUACION CREEK NEAR MOUTH (S-2)

VARIATION IN TIME OF MAJOR CATIONS EVACUACION CREEK FROM BELOW PARK CANYON TO MOUTH OCTOBER 1974 - SEPTEMBER 1975

FIGURE II-45



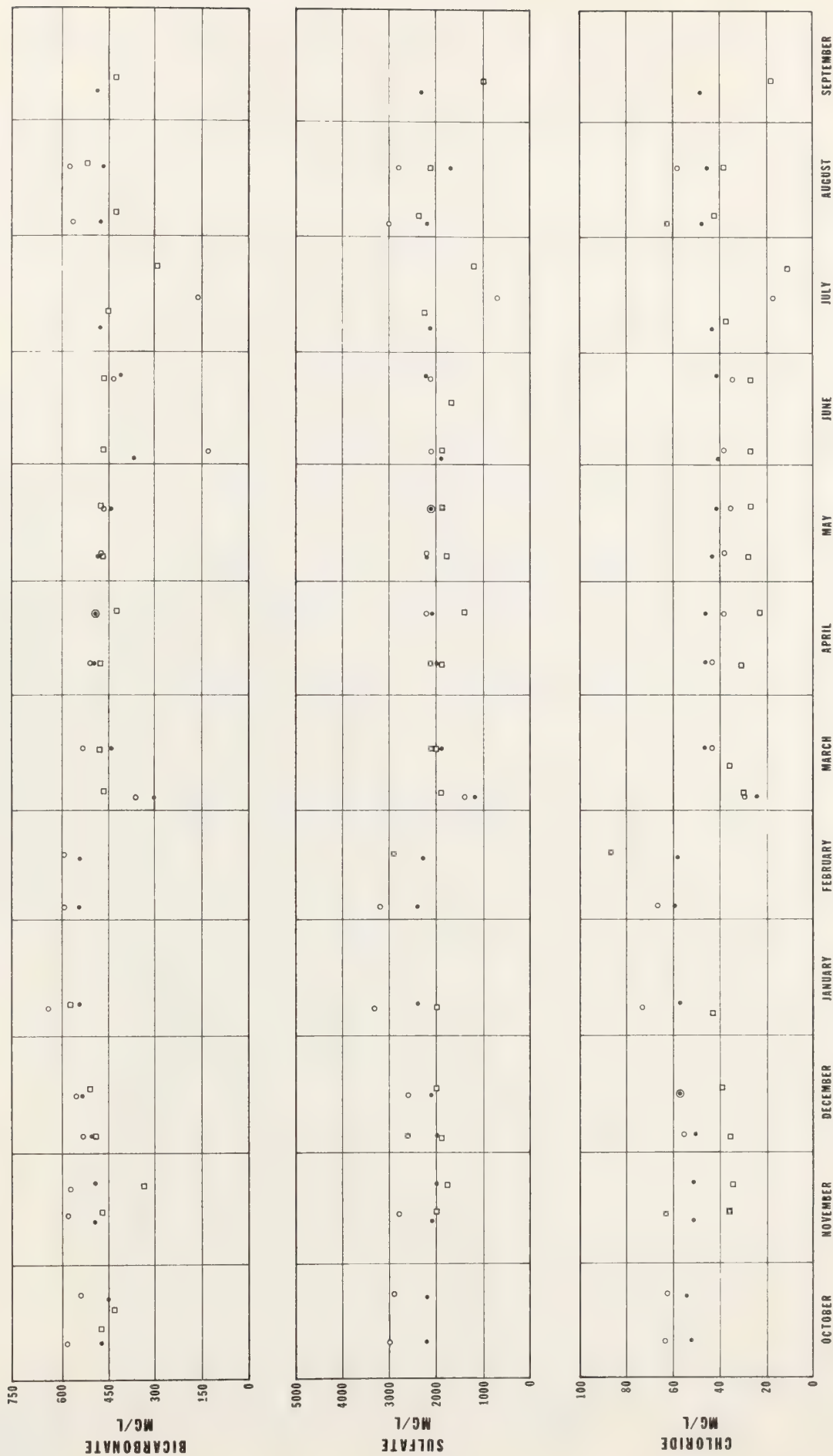


LEGEND

- EVACUATION CREEK BELOW PARK CANYON (S-7)
- EVACUATION CREEK AT WATSON, UTAH (S-6)
- EVACUATION CREEK NEAR MOUTH (S-2)

VARIATION IN TIME OF MAJOR CATIONS
EVACUATION CREEK FROM BELOW PARK CANYON TO MOUTH
OCTOBER 1975 - SEPTEMBER 1976



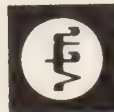


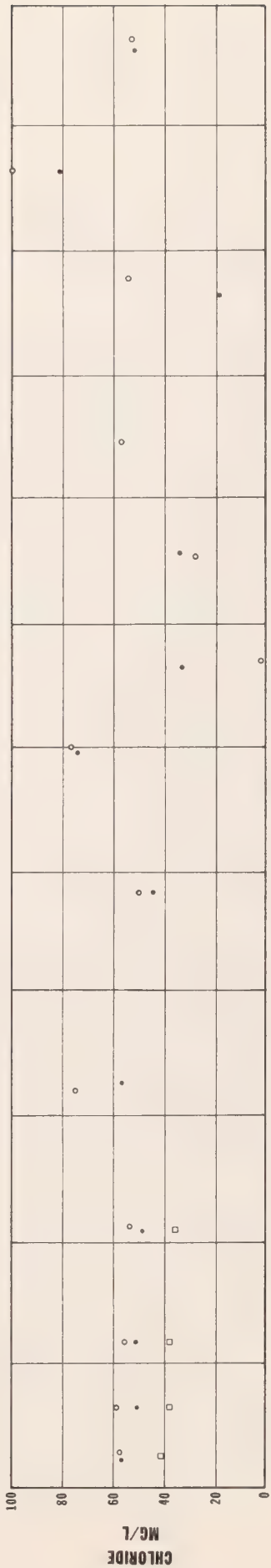
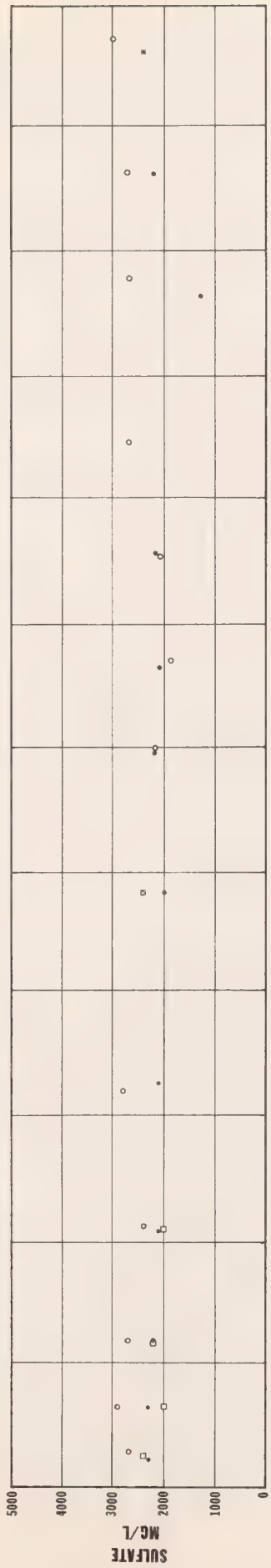
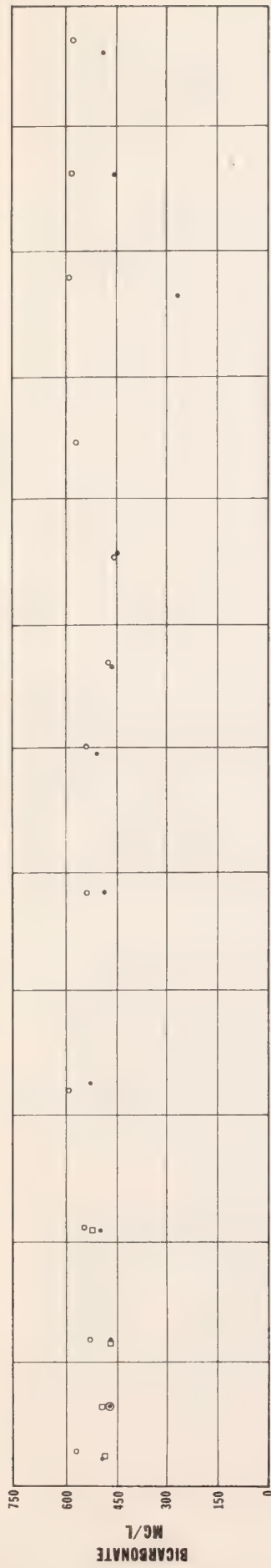
LEGEND

- EVACUATION CREEK BELOW PARK CANYON, UTAH (S-2)
- EVACUATION CREEK AT WATSON, UTAH (S-6)
- EVACUATION CREEK NEAR MOUTH (S-2)

VARIATION IN TIME OF MAJOR ANIONS
EVACUATION CREEK FROM BELOW PARK CANYON TO MOUTH
OCTOBER 1974 - SEPTEMBER 1975

FIGURE II-47





LEGEND

- EVACUATION CREEK BELOW PARK CANYON (S-7)
- EVACUATION CREEK AT WATSON, UTAH (S-6)
- EVACUATION CREEK NEAR MOUTH (S-2)

VARIATION IN TIME OF MAJOR ANIONS
EVACUATION CREEK FROM BELOW PARK CANYON TO MOUTH
OCTOBER 1975 - SEPTEMBER 1976



above 3,000 mg/l occurred at Station S-6 during January and February 1975 and several readings were recorded below 2,000 mg/l from March through September 1975, primarily at stations S-2 and S-7.

Chloride concentrations followed a more erratic pattern in water year 1976 than during the previous year. Although readings were similar in October 1974 through January 1975, concentrations were noticeably lower in February (50 mg/l in 1976 compared to 68 mg/l in 1975) and April (19 mg/l to 44 mg/l) and higher in March (76 mg/l compared to 37 mg/l), and June 1976 (58 mg/l to 39 mg/l), compared to the previous year. These marked shifts in concentration levels from month to month are attributed to the extreme daily variations in streamflow during highflow (February through July 1976). No carbonate was reported during the year with the exception of a 4.2 mg/l reading at Station S-6 during highflow. Sulfide and bromide values remained consistently low throughout the year with mean levels of sulfide ranging from 1.1 mg/l to 0.0 mg/l, and mean levels of bromide from 0.4 mg/l to 0.2 mg/l. Fluoride was higher at all stations during baseflow, reaching a maximum of 2.3 mg/l at Station S-6 in 1976, compared to a maximum of 1.1 at Station S-7 during 1975.

Biochemical Constituents: All three parameters shown on figures II-49 and II-50 followed patterns similar to the previous year. Dissolved oxygen generally ranged between 6 mg/l and 12 mg/l, while chemical oxygen demand (COD) levels remained between 15 mg/l and 60 mg/l, with several readings over 60 mg/l reported during March, May through July, and September 1975. Similarly, total coliforms remained barely above detectable limits throughout the second year, with no high readings during June through July, as occurred during the previous year.

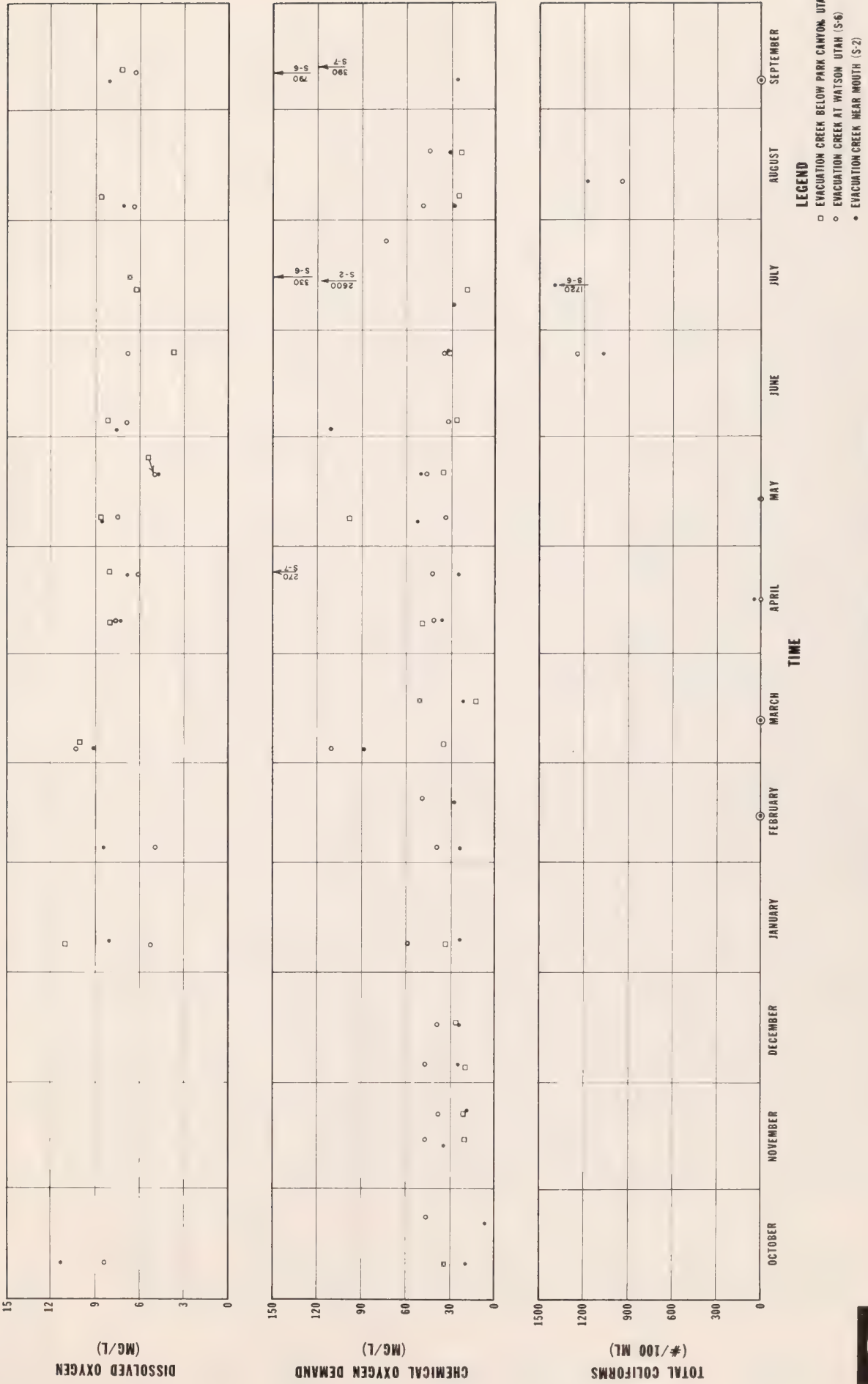
Carbon dioxide was highest at Station S-6 during baseflow (mean values) although maximum and minimum values were similar at Station S-2 during the same period. The greatest fluctuation occurred at Station S-6 during highflow, with a maximum value of 54.0 mg/l reported. Biochemical oxygen demand (BOD) was similar at stations S-2 and S-6 (1.1 mg/l mean values) during baseflow; no samples were taken during highflow. COD was lower during highflow at both stations in 1976 (53 µg/l compared to 77 µg/l at S-6; 40 µg/l compared to 47 µg/l at S-2).

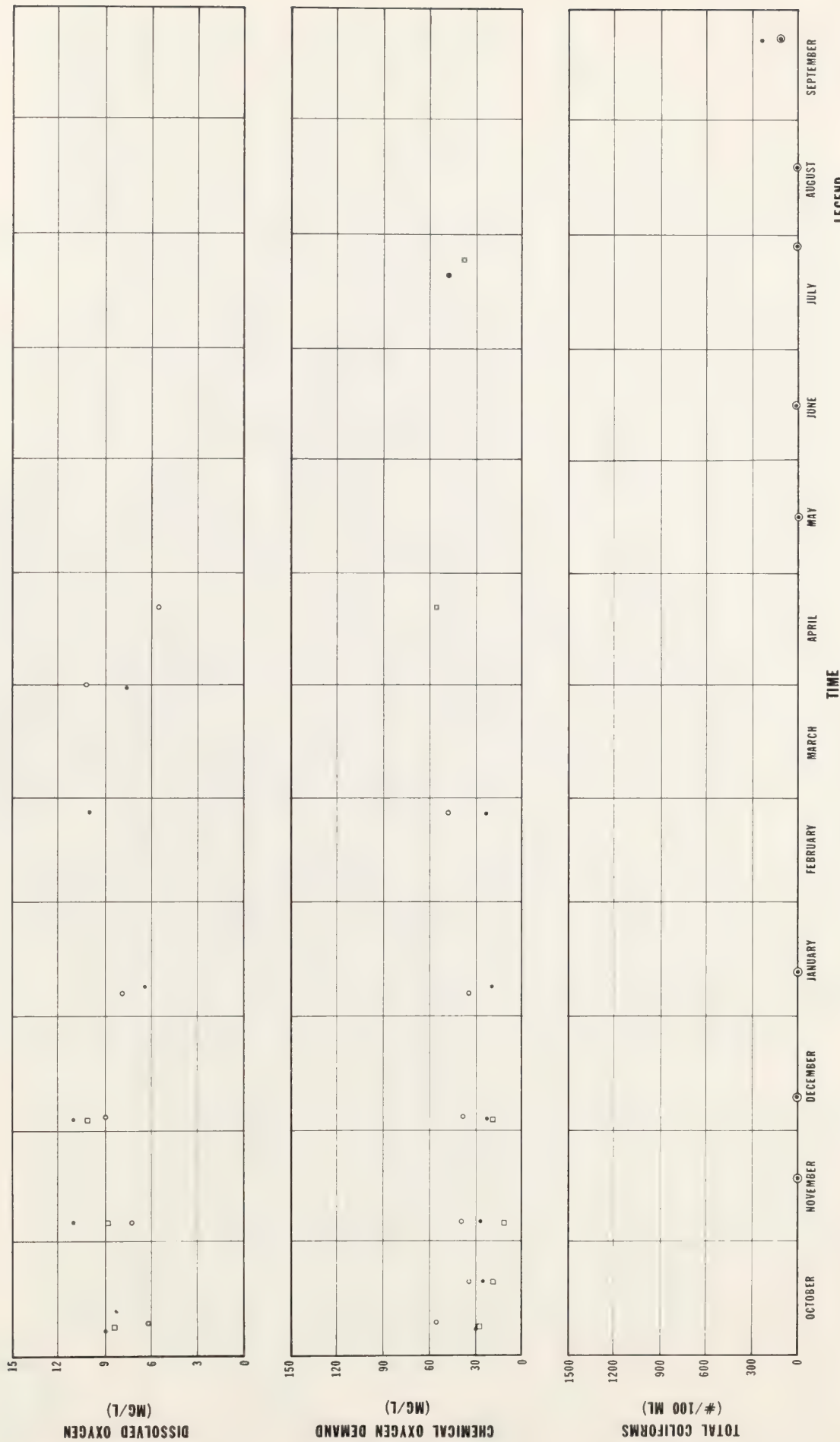
Suspended organic carbon (SOC) was sampled only during highflow, with a maximum of 0.3 mg/l recorded at both stations S-2 and S-6. Total organic carbon (TOC) exhibited slightly higher mean values during baseflow (ranging from 23 µg/l at S-7 to 13 µg/l at S-2), although the highest levels (34.0 µg/l) were reported at Station S-6 during highflow. Total inorganic carbon (TIC) samples were reported during baseflow only, with highest values at Station S-6 (maximum of 123 µg/l). Dissolved organic carbon (DOC) mean levels for both years were higher at all stations during baseflow (24 µg/l compared to 8.8 during highflow at S-2;



VARIATION IN TIME OF BIOCHEMICAL CONSTITUENTS EVACUATION CREEK FROM BELOW PARK CANYON TO MOUTH OCTOBER 1974 - SEPTEMBER 1975

FIGURE II-49





LEGEND

- EVACUACION CREEK BELOW PARK CANYON (S-7)
- EVACUACION CREEK AT WATSON, UTAH (S-6)
- EVACUACION CREEK NEAR MOUTH (S-2)

VARIATION IN TIME OF BIOCHEMICAL CONSTITUENTS

EVACUACION CREEK FROM BELOW PARK CANYON TO MOUTH

OCTOBER 1975 - SEPTEMBER 1976

FIGURE II-50



16 µg/l compared to 9.4 µg/l at S-6). Fecal coliforms were higher during highflow, with maximum values (6620 count/100 ml) reported at Station S-2. Mean levels for fecal strep were also higher at Station S-2 during highflow (851 count/100 ml compared to 529), but values reported at Station S-6 were higher during baseflow (740 count/100 ml compared to 343). Chlorophyll A was 5.0 µg/l at S-6 compared to 2.3 during baseflow; 5.8 µg/l at S-2 compared to 3.1 µg/l, and chlorophyll B was 3 µg/l at S-6 compared to 1.8 during baseflow (4.1 µg/l compared to 1.7 at S-2) mean values were higher during highflow, but there was little variation between maximum and minimum values during both baseflow and highflow periods (Station S-2 reached maximums of 13 µg/l and 18 µg/l for Chlorophyll A, respectively, and 5.4 µg/l and 10 µg/l for Chlorophyll B). At Station S-6, the maximum level during both periods was 19 µg/l for Chlorophyll A; Chlorophyll B reached a maximum of 6.60 µg/l during baseflow and 4.0 µg/l during highflow.

Macronutrients: Nitrate generally remained at similar levels, during the second year of monitoring but with fewer high readings, as shown on figures II-51 and II-52. Mean levels during baseflow at S-2 were 0.53 µg/l in 1976 compared to 0.24 µg/l in 1975, and 0.03 µg/l compared to 0.80 µg/l at S-6. During highflow, Station S-2 had mean levels of 1.23 µg/l in 1976 compared to 1.3 µg/l in 1975, and at S-6, the 1976 levels were 0.92 µg/l compared to 1.3 µg/l. At Station S-7 values substantially exceeded the 2.5 mg/l level during November and December 1975, and January, August, and September 1976.

Ammonia levels showed the same range in the lower readings (below 0.06 mg/l) during both years, but the numerous higher readings during October through December 1974, and March and May 1975 were not repeated. Phosphorus also remained at similar lower values during the second year but with fewer readings over 0.20 mg/l during highflow than in March through June 1975.

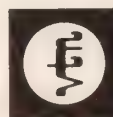
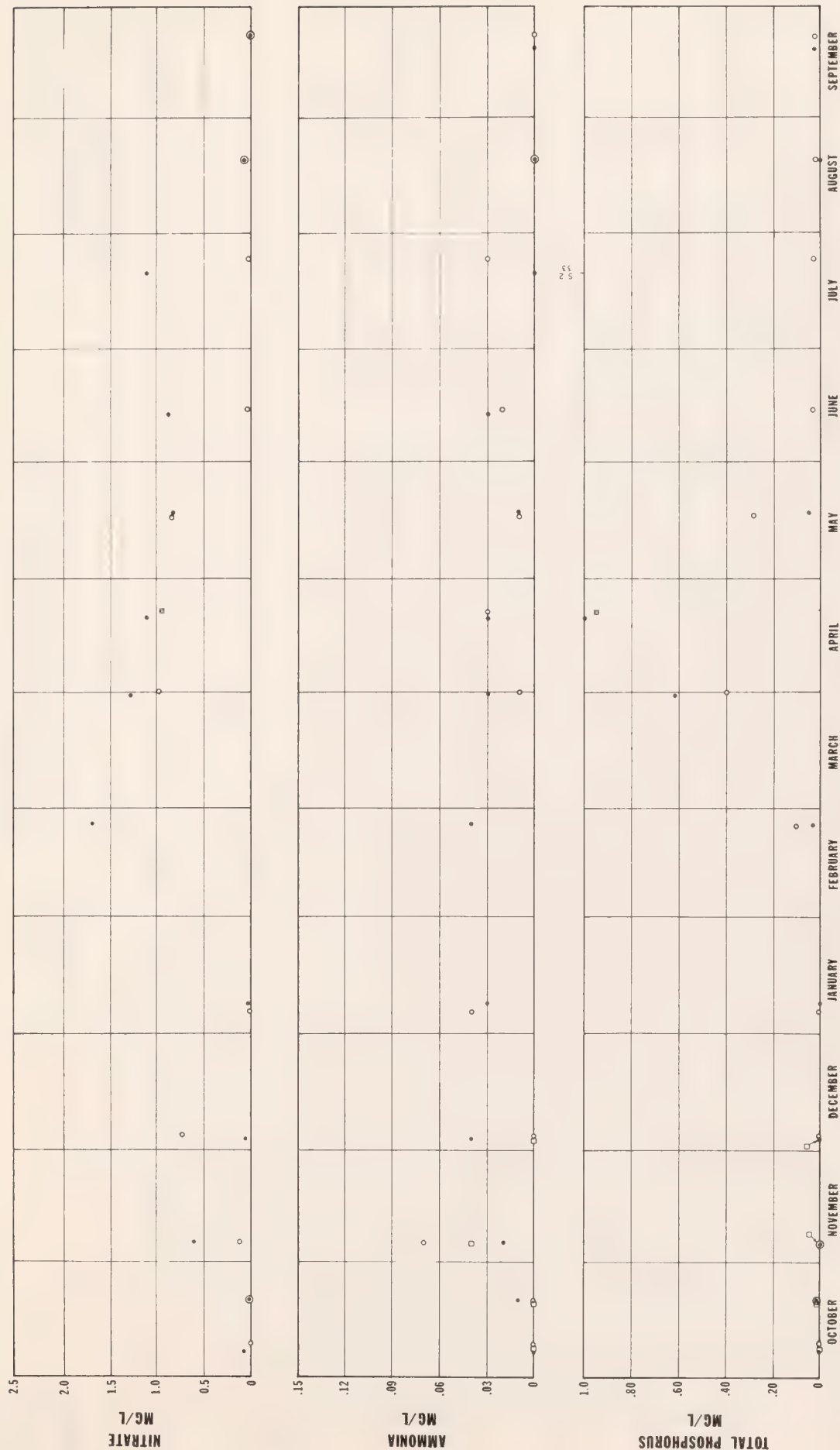
Although there was little variation in nitrite readings at individual stations between baseflow and highflow during 1976, concentrations showed a steady increase between upstream and downstream stations during both periods increasing from a maximum of 0.03 mg/l to 0.09 mg/l during baseflow, and from 0.01 mg/l to 0.02 mg/l during high flow. Kjeldahl nitrogen exhibited an erratic pattern, with substantially higher readings at station S-6 during highflow (maximum of 2.30 mg/l compared to 0.82). Orthophosphate readings were slightly lower during 1976 at both stations S-2 and S-6 during highflow (maximum of 0.03 mg/l at both stations in 1976 compared to 0.12 mg/l during 1975) and showed no variation between stations within baseflow and highflow periods.

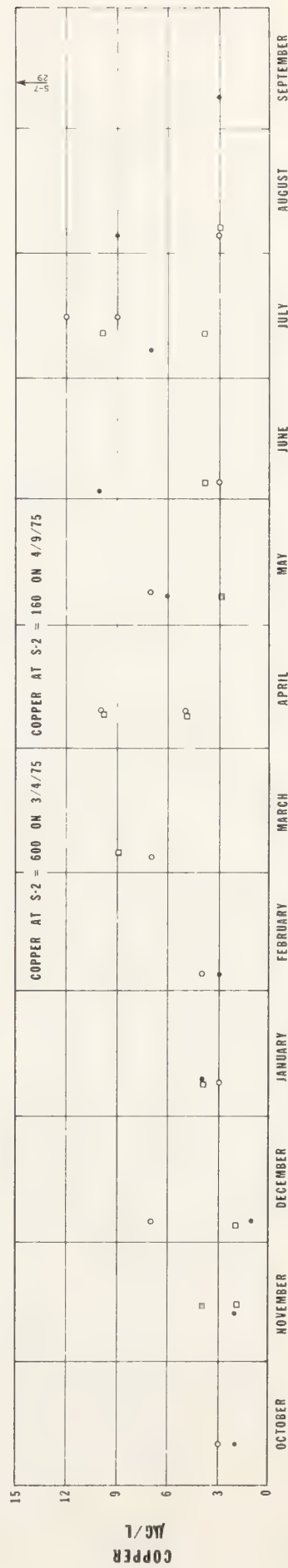
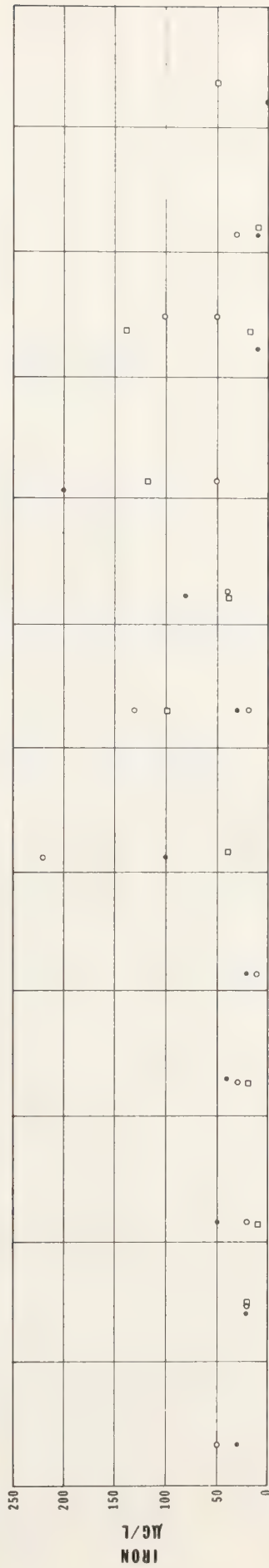
Micronutrients: Concentration levels of zinc, iron, and copper remained generally consistent with first year values (see figures II-53 and II-54). Zinc ranged between very low values and



VARIATION IN TIME OF REPRESENTATIVE MACRONUTRIENTS
 EVACUATION CREEK FROM BELOW PARK CANYON TO MOUTH
 OCTOBER 1974 - SEPTEMBER 1975







LEGEND

- EVACUATION CREEK BELOW PARK CANYON, UTAH (S-7)
- EVACUATION CREEK AT WATSON, UTAH (S-6)
- EVACUATION CREEK NEAR MOUTH (S-2)

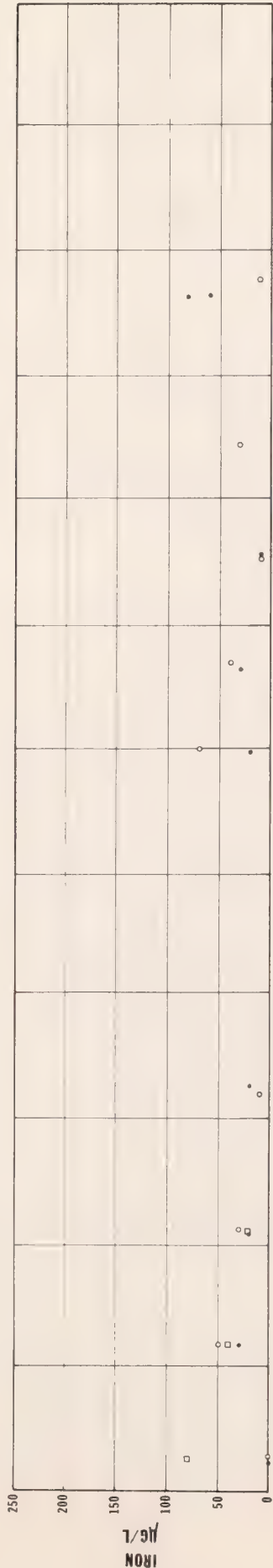
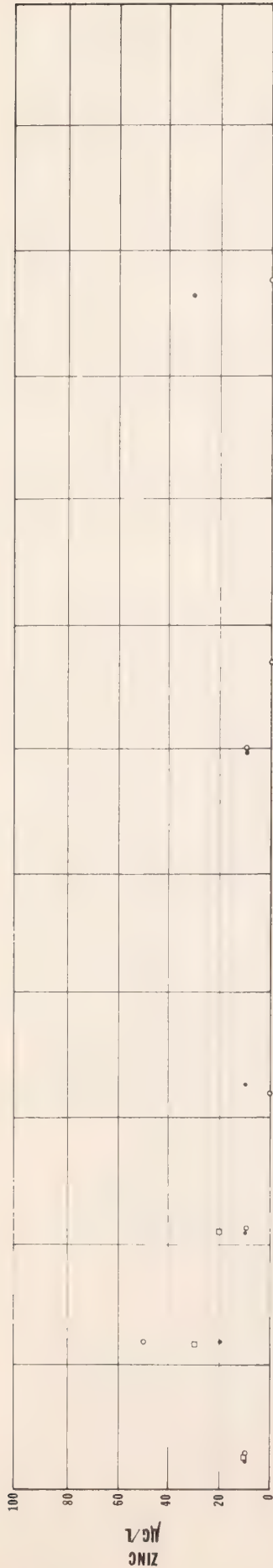
VARIATION IN TIME OF SOME MICRONUTRIENTS

EVACUATION CREEK FROM BELOW PARK CANYON TO MOUTH

OCTOBER 1974 - SEPTEMBER 1975

FIGURE II-53





LEGEND
 □ EVACUATION CREEK BELOW PARK CANYON (S-7)
 ○ EVACUATION CREEK AT WATSON, UTAH (S-6)
 • EVACUATION CREEK NEAR MOUTH (S-2)

VARIATION IN TIME OF SOME MICRONUTRIENTS
 EVACUATION CREEK FROM BELOW PARK CANYON TO MOUTH
 OCTOBER 1975 - SEPTEMBER 1976

FIGURE 11-54

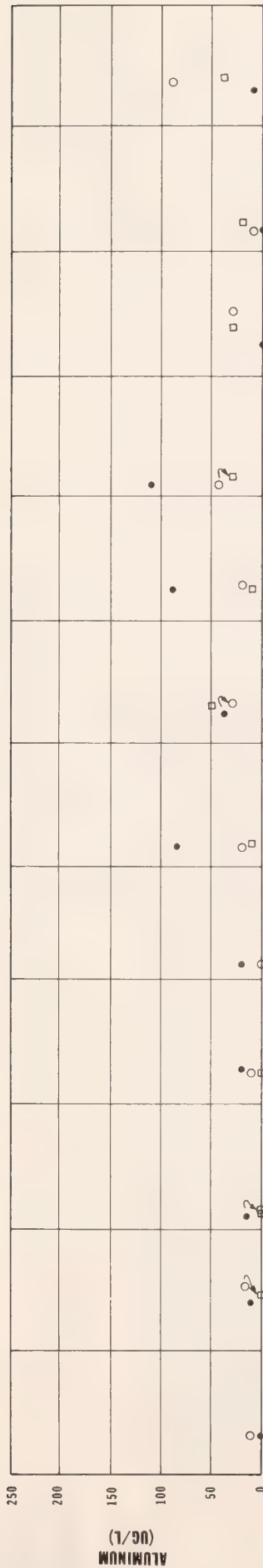


40 µg/l, with the exception of one 50 µg/l reading in November at Station S-6. Iron remained below 100 µg/l throughout the year in contrast to a number of readings above 100 µg/l during April, June, and July 1975. There was virtually no change in copper concentrations, which fell below 9 µg/l for most of the year, peaking at 12 µg/l during July of both years. As expected, mean boron concentrations for both years during baseflow were higher at both stations than during highflow (1924 µg/l compared to 763 µg/l at S-6; 1731 µg/l to 1021 µg/l at S-2), and manganese levels were considerably higher at stations S-2 (82 µg/l compared to 36 µg/l) and S-6 (195 µg/l to 14 µg/l) during the same period. Mean values for molybdenum increased moving downstream from Station S-6 (27 µg/l) to Station S-2 (45 µg/l), but showed little difference during both years between baseflow and highflow (27 µg/l and 30 µg/l at S-6; 45 µg/l and 42 µg/l at S-2). Cobalt levels were generally below detection limits throughout both years and between stations, while silica steadily decreased (from 10.3 µg/l to 9.0 µg/l) moving downstream during baseflow but remained fairly constant between stations S-2 (10 µg/l) and S-6 (10.5 µg/l) during highflow.

Trace Metals: Several of the trace metals had higher baseflow than highflow values, including barium (71 µg/l to 6 µg/l at S-2), chromium (5 µg/l to 3 µg/l at S-2), lithium (122 µg/l to 90 µg/l at S-2; 103 µg/l to 65 µg/l at S-6), mercury (1 µg/l to 0.02 µg/l at S-2; 0.02 µg/l to 0.03 µg/l at S-6), and nickel (6 µg/l to 3 µg/l at S-2; 8 µg/l to 2 µg/l at S-6). A few constituents showed increased mean concentration levels moving downstream during both baseflow and highflow, including chromium (0.02 µg/l to 0.01 µg/l and 0.03 µg/l to 0.02 µg/l). Vanadium levels were higher upstream, decreasing from 1.7 µg/l to 1.3 µg/l during baseflow and from 1.6 µg/l to .6 µg/l during highflow. Bismuth, germanium, tin, titanium, and zirconium levels were generally below detection limits during both years of monitoring. Aluminum concentrations increased moving downstream during baseflow from 37 µg/l at S-6 to 19 µg/l at S-2) but remained fairly constant during highflow (45 µg/l at S-6; 49 µg/l at S-2). All gallium readings were below 30 µg/l except for a less than 40 µg/l baseflow reading at Station S-6. Lead concentrations remained constant at a maximum 3.0 µg/l level during baseflow but increased from 1.0 µg/l to 4.0 µg/l between stations S-6 and S-2 during highflow (figures II-55 and II-56).

Selenium increased moving downstream during baseflow (from 1.0 µg/l to 1.2 µg/l) but remained constant during highflow (3 µg/l). No silver was detectable except for a baseflow reading of 1.0 µg/l at Station S-6.

There was no significant change between highflow and baseflow concentrations of aluminum, beryllium, bismuth, gallium, lead, and selenium. No perceivable pattern was evident for nickel and vanadium, and zirconium showed consistent values throughout the year (less than 140 µg/l) with the exception of a higher baseflow reading (less than 170 µg/l) at Station S-6.



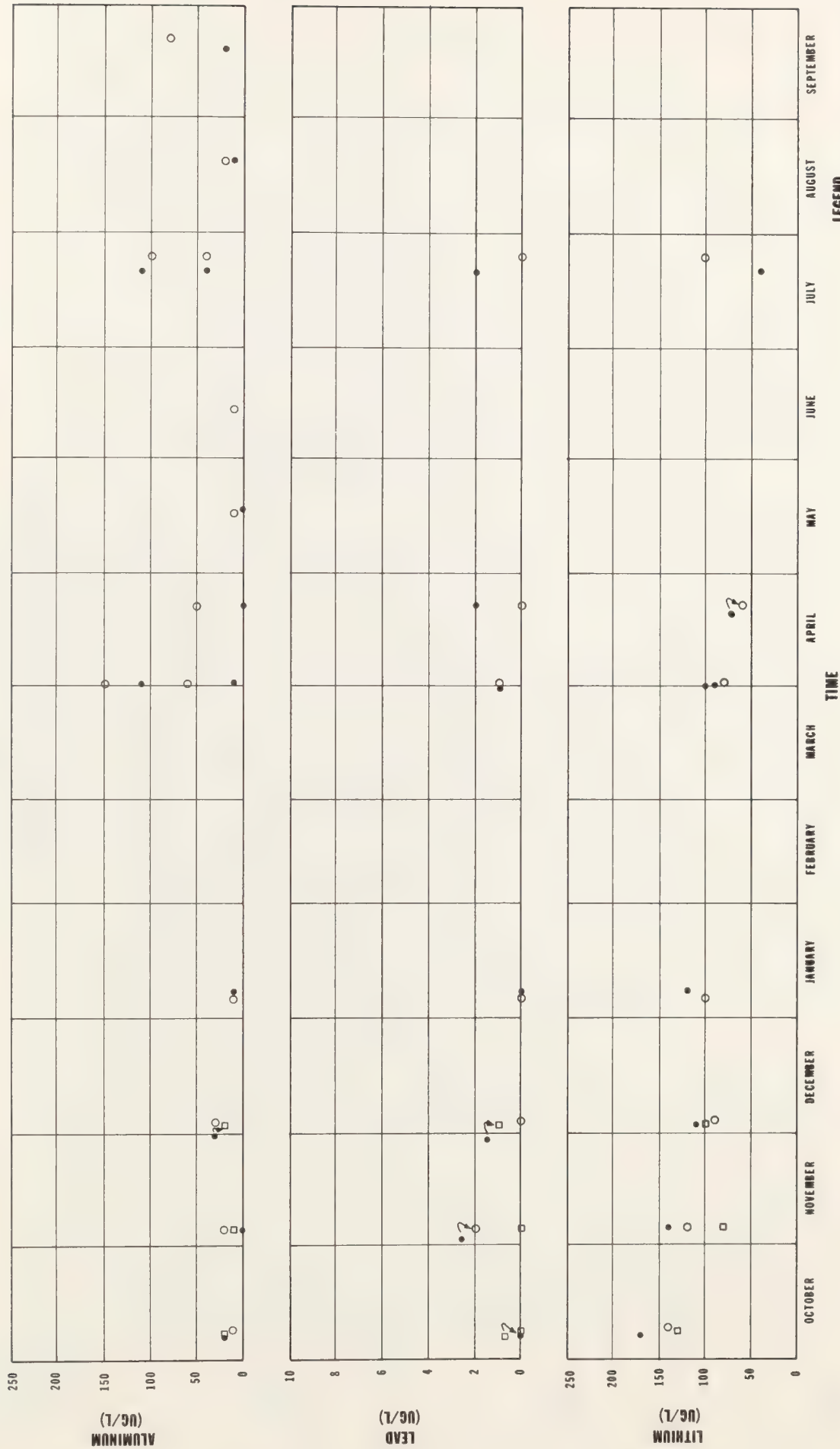
LEGEND

- EVACUATION CREEK BELOW PARK CANYON (S-7)
- EVACUATION CREEK AT WATSON, UTAH (S-6)
- EVACUATION CREEK NEAR MOUTH (S-2)

VARIATION IN TIME OF SOME TRACE METALS
EVACUATION CREEK FROM BELOW PARK CANYON TO MOUTH
OCTOBER 1974 - SEPTEMBER 1975

FIGURE 11-55





LEGEND
 □ EVACUATION CREEK BELOW PARK CANYON (S-7)
 ○ EVACUATION CREEK AT WATSON, UTAH (S-6)
 ● EVACUATION CREEK NEAR MOUTH (S-2)

VARIATION IN TIME OF SOME TRACE METALS
 EVACUATION CREEK FROM BELOW PARK CANYON TO MOUTH
 OCTOBER 1975 - SEPTEMBER 1976



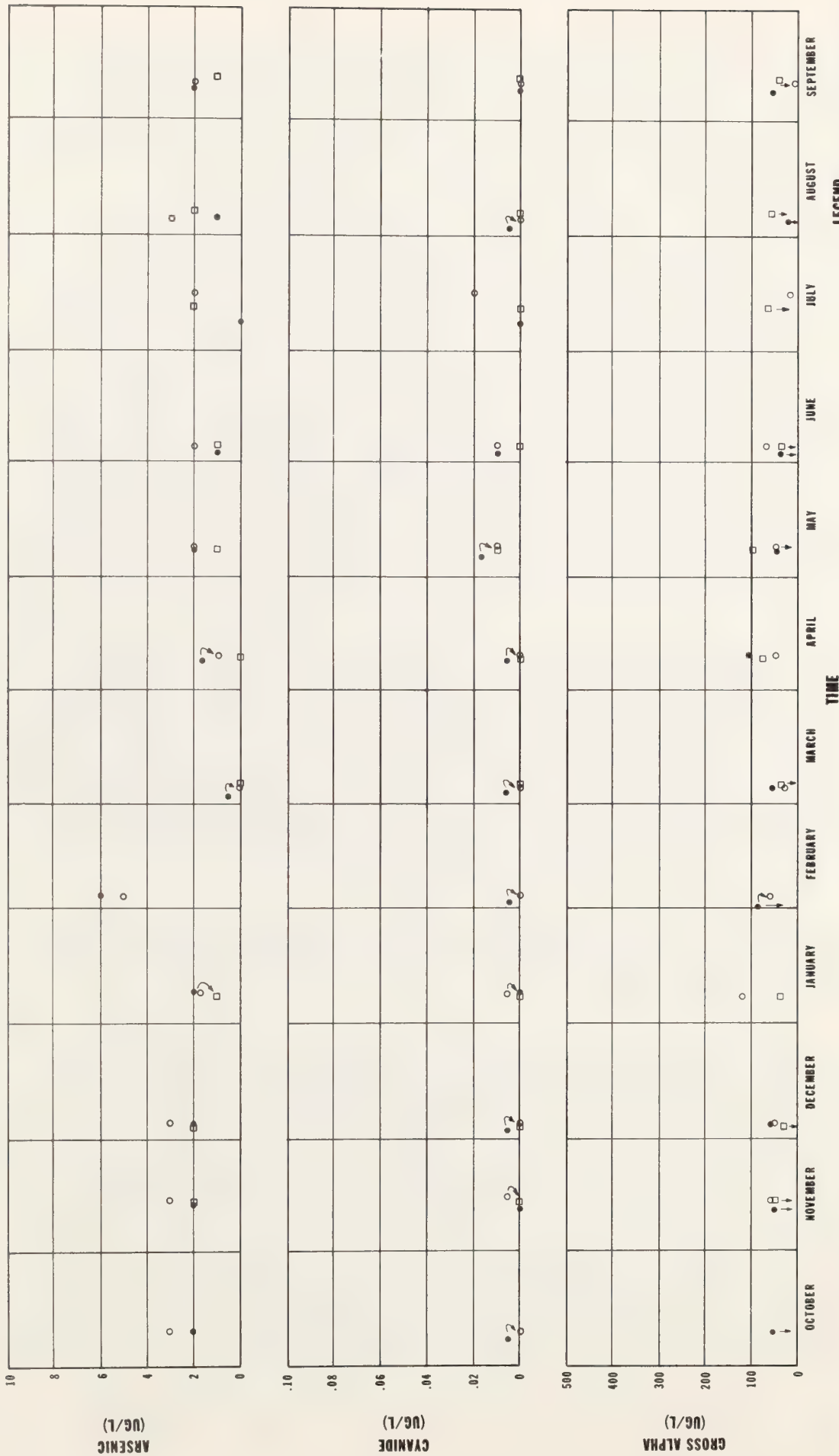
There was no significant change between highflow and baseflow concentrations of aluminum, beryllium, bismuth, gallium, lead, and selenium. No perceivable pattern was evident for nickel and vanadium, and zirconium showed consistent values throughout the year (less than 140 $\mu\text{g/l}$) with the exception of a higher baseflow reading (less than 170 $\mu\text{g/l}$) at Station S-6.

Trace Non-Metals: Arsenic levels were generally consistent throughout the second year ranging from 0 $\mu\text{g/l}$ to 3 $\mu\text{g/l}$, with a slight increase to a maximum 5 $\mu\text{g/l}$ at Station S-6 during baseflow. Cyanide remained below the detectable limit during baseflow (except for a 0.01 mg/l reading at Station S-7), with very low maximum concentrations (.02 mg/l) reported during high flow (figures II-57 and II-58). No detectable MBAS was reported during highflow, with low levels (0.4 mg/l maximum at Station S-6) occurring during baseflow. Although phenol mean values showed little variation throughout the year (ranging between 3 $\mu\text{g/l}$ and 5 $\mu\text{g/l}$), the range of reported levels fluctuated for individual stations between highflow and baseflow (maximum of 24 $\mu\text{g/l}$ for the year during highflow at S-6; maximum of 25 $\mu\text{g/l}$ during baseflow at S-2). No pesticides or herbicides were reported from the limited number of samples taken during highflow.

Radioactive Constituents: Cesium 137 was present in barely detectable amounts (less than 10 pc/l throughout the year. Gross alpha concentrations were higher downstream during both baseflow (maximum of 280 $\mu\text{g/l}$ at S-2 compared to 120 $\mu\text{g/l}$ at S-6) and highflow (maximum of 110 $\mu\text{g/l}$ at S-2 compared to 67 $\mu\text{g/l}$ at S-6). Gross beta (Cesium 137) and gross beta (Strontium 90) concentrations were also higher during the baseflow than highflow with maximum levels of 170 pc/l and 140 pc/l (both recorded at S-6) compared to maximum levels of 30 pc/l and 25 pc/l recorded at S-2.

Water Quality: The Dry Washes - Southam Canyon, Hells Hole Canyon, and Asphalt Wash

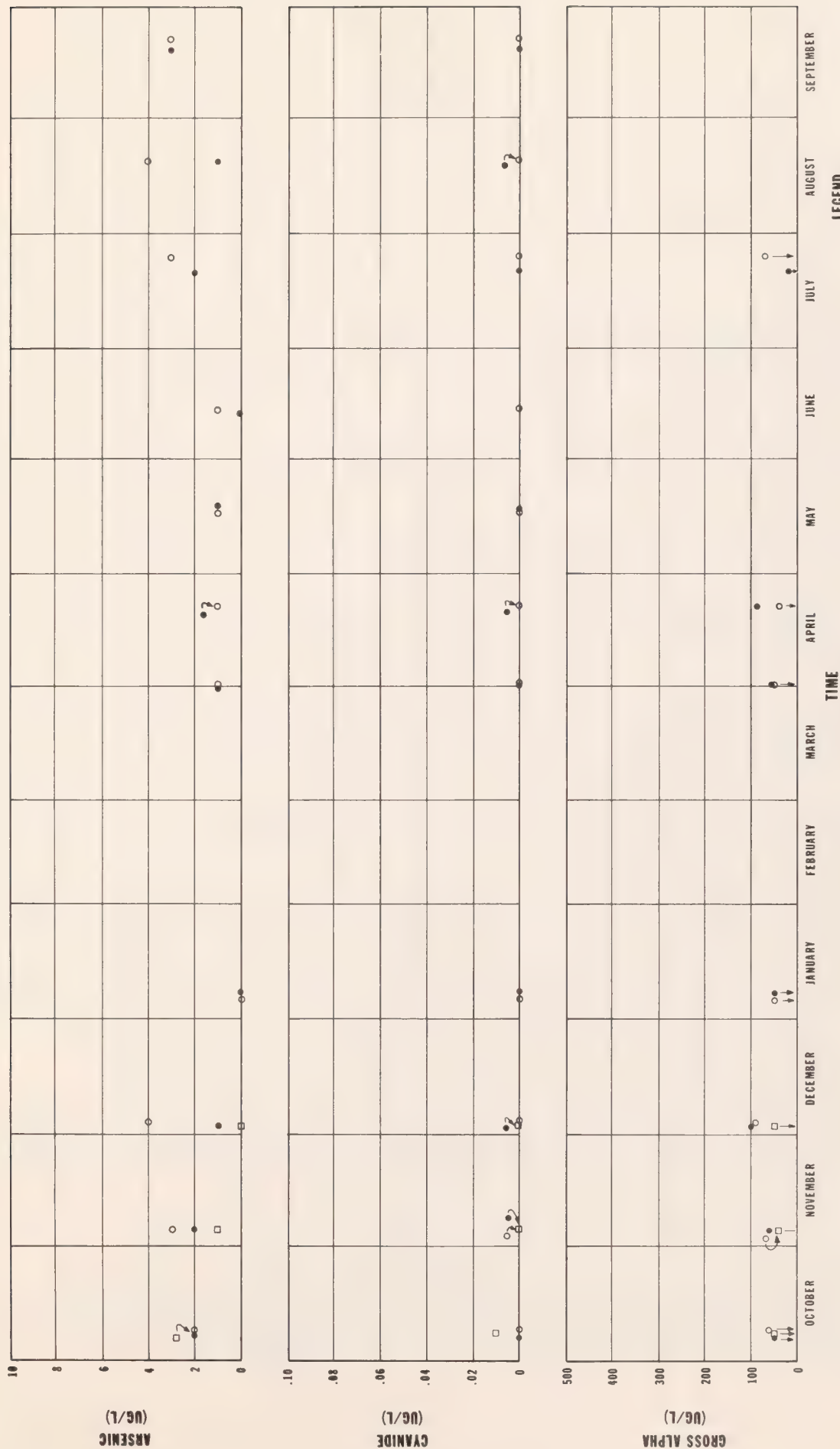
The results of water quality sampling for both years of monitoring in Hells Hole Canyon, Southam Canyon and Asphalt Wash are summarized on Table II-5. Although the quality of water in these three washes is not identical, its natural variation is such that it is reasonable to combine the results to obtain an overall idea of the quality of water when flow does occur. Grab samples taken at rising stage and falling stage during a flow event are likely to be less comparable than comparing the rising stage samples from different washes. The most appropriate differentiation is in the source of flow as shown in Table II-5. Calcium, sodium, sulfate, and bicarbonate continued to be the dominant dissolved elements. Iron, manganese, and arsenic did not reach concentrations in excess of federal drinking water standards in



VARIATIONS WITH TIME OF SEVERAL TRACE NON-METALS INCLUDING RADIOACTIVE CONSTITUENTS

EVACUATION CREEK FROM BELOW PARK CANYON TO MOUTH
OCTOBER 1974 - SEPTEMBER 1975





LEGEND

- EVACUATION CREEK BELOW PARK CANYON (S-7)
- EVACUATION CREEK AT WATSON, UTAH (S-6)
- EVACUATION CREEK NEAR MOUTH (S-2)

VARIATIONS WITH TIME OF SEVERAL TRACE NON-METALS INCLUDING RADIOACTIVE CONSTITUENTS

EVACUATION CREEK FROM BELOW PARK CANYON TO MOUTH

OCTOBER 1975 - SEPTEMBER 1976

FIGURE II-58



TABLE II-5
SUMMARY OF WASHES WATER QUALITY
(Hells Hole Canyon, Asphalt Wash, and Southam Canyon)
(AUGUST 1974 TO SEPTEMBER 1976)

Parameters	Rainfall Runoff					Snowmelt Runoff				
	Number of Samples	Mean	Standard Deviation	Maximum	Minimum	Number of Samples	Mean	Standard Deviation	Maximum	Minimum
GENERAL CHARACTERISTICS										
Alkalinity (mg/l)	6	120	59	189	39	4	99	29	123	62
Dissolved Solids (mg/l)	5	888	919	2520	351	0	—	—	—	—
Hardness (mg/l)	6	472	530	1400	68	4	53	17	77	42
Non-carbonate Hardness (mg/l)	0	—	—	—	—	4	0	0	0	0
Oil and Grease (mg/l)	2	—	—	—	—	0	—	—	55	—
pH (units)	0	—	—	—	—	4	7.9	17	8.1	7.7
Specific Conductance (umhos)	5	1388	911	2670	595	3	237	144	400	130
Streamflow (CFS)	3	18.37	19.56	39	10	4	0.44	0.77	1.6	7.5
Temperature (°C)	3	15.8	5.0	20.0	10.2	4	77.5	155	310	0
MAJOR CATIONS										
Calcium (mg/l)	6	154	178	470	19	4	18	7	28	13
Magnesium (mg/l)	6	21.5	21.7	57	3.9	4	1.9	8	2.7	1.0
Potassium (mg/l)	6	6.2	3.2	18	2.5	4	3.0	1.4	4.5	1.6
Sodium (mg/l)	6	113	51	170	39	4	35	25	59	13
SAR	6	3.0	1.4	4.4	1.0	4	2.2	1.6	3.6	7
% Sodium	6	45	23	71	21	4	52	22	72	29
Strontium (mg/l)	5	1302	1260	3500	340	0	—	—	—	—
MAJOR ANIONS										
Bicarbonate (mg/l)	6	146	72	231	47	4	120	35	150	75
Carbonate (mg/l)	2	0	0	0	0	4	0	0	0	0
Chloride (mg/l)	6	9.4	3.2	12	4.1	4	4.1	2.6	6.9	1.5
Sulfate (mg/l)	6	407	325	1600	34	4	24.1	17.5	55	7.9
Sulfide (mg/l)	5	1	1	2	0	0	—	—	—	—
Fluoride (mg/l)	6	4	1	5	3	4	2	1	2	1
Bromide (mg/l)	2	0	0	0	0	0	—	—	—	—
BIOCHEMICAL CONSTITUENTS										
Carbon Dioxide (mg/l)	2	25	18	37	12	4	2.6	79	37	1.9
Dissolved Oxygen (mg/l)	2	79	9	85	72	4	11.6	28	12.0	11.4
BOD (mg/l)	0	—	—	—	—	0	—	—	—	—
COD (mg/l)	0	—	—	—	—	0	—	—	—	—
SOC (mg/l)	0	—	—	—	—	0	—	—	—	—
TOC (mg/l)	0	—	—	—	—	0	—	—	—	—
TIC (mg/l)	0	—	—	—	—	0	—	—	—	—
DOC (mg/l)	0	—	—	—	—	0	—	—	—	—
Total Coliforms (count/100 ml)	0	—	—	—	—	0	—	—	—	—
Fecal Coliforms (count/100 ml)	0	—	—	—	—	0	—	—	—	—
Chlorophyll A (ug/l)	0	—	—	—	—	0	—	—	—	—
Chlorophyll B (ug/l)	0	—	—	—	—	0	—	—	—	—
Fecal Strept (count/100 ml)	0	—	—	—	—	0	—	—	—	—
MACRO NUTRIENTS										
Ammonia (mg/l)	5	03	04	09	00	0	—	—	—	—
Nitrite (mg/l)	5	08	08	02	21	0	—	—	—	—
Nitrate (mg/l)	5	199	101	340	77	0	—	—	—	—
Kjeldahl Nitrogen (mg/l)	5	10.2	15.2	37	1.2	0	—	—	—	—
Orthophosphate (mg/l)	6	04	05	11	00	4	06	02	09	04
Total Phosphorus (mg/l)	5	4	5.57	13.33	01	0	—	—	—	—
MICRO NUTRIENTS										
Boron (ug/l)	6	173	117	330	50	4	125	82	230	50
Copper (ug/l)	5	21	15	45	8	0	—	—	—	—
Iron (ug/l)	6	165	144	420	30	4	207	63	300	160
Manganese (ug/l)	3	180	294	520	10	4	8	5	10	0
Zinc (ug/l)	5	92	40	130	40	0	—	—	—	—
Molybdenum (ug/l)	2	6	0	6	6	0	—	—	—	—
Cobalt (ug/l)	2	300	0	300	300	0	—	—	—	—
Silica (ug/l)	6	10.6	4.3	15	4.4	4	4.1	2.5	5.5	5.2
TRACE METALS										
Aluminum (ug/l)	3	43	45	90	0	0	—	—	—	—
Barium (ug/l)	2	150	71	200	100	0	—	—	—	—
Beryllium (ug/l)	2	15	7	20	10	0	—	—	—	—
Bismuth (ug/l)	0	—	—	—	—	0	—	—	—	—
Cadmium (ug/l)	2	0	0	0	0	0	—	—	—	—
Chromium (ug/l)	2	1	1	2	0	0	—	—	—	—
Gallium (ug/l)	0	—	—	—	—	0	—	—	—	—
Germanium (ug/l)	0	—	—	—	—	0	—	—	—	—
Lead (ug/l)	2	0	0	0	0	0	—	—	—	—
Lithium (ug/l)	5	26	23	60	10	0	—	—	—	—
Mercury (ug/l)	5	0	0	0	0	0	—	—	—	—
Nickel (ug/l)	2	0	0	0	0	0	—	—	—	—
Selenium (ug/l)	5	1	8	2	0	0	—	—	—	—
Silver (ug/l)	0	—	—	—	—	0	—	—	—	—
Tin (ug/l)	0	—	—	—	—	0	—	—	—	—
Titanium (ug/l)	2	—	—	—	—	0	—	—	—	—
Vanadium (ug/l)	0	—	—	—	—	0	—	—	—	—
Zirconium (ug/l)	0	—	—	—	—	0	—	—	—	—

TABLE II-5 (continued)

	Rainfall Runoff				Snowmelt Runoff					
	Number of Samples	Mean	Standard Deviation	Maximum	Minimum	Number of Samples	Mean	Standard Deviation	Maximum	Minimum
TRACE NON-METALS	Arsenic (ug/l)	9	16	37	1	0	—	—	—	—
	Cyanide (mg/l)	00	00	01	00	0	—	—	—	—
	MBAS (mg/l)	1	0	1	1	0	—	—	—	—
	Phenols (ug/l)	5	5	8	1	0	—	—	—	—
	Pesticides (ug/l)	0	—	—	—	0	—	—	—	—
RADIOACTIVE CONSTITUENTS	Herbicides (ug/l)	0	—	—	—	0	—	—	—	—
	Cesium 137 (PC/l)	0	—	—	—	—	—	—	—	—
	Gross Alpha as U-Nat (ug/l)	0	—	—	—	—	—	—	—	—
	Gross Beta (SR-90) (PC/l)	0	—	—	—	—	—	—	—	—
	Gross Beta (CS-137) (PC/l)	0	—	—	—	—	—	—	—	—

the samples analyzed during either year. Caution should be applied in interpreting sampling results for the dry washes because of the high degree of variability in the data and erratic streamflow patterns.

Streambed Analysis

The results of the streambed mineral analysis are given on tables II-6 through II-10. The results generally corresponded to the first-year analysis; i.e., two major sediment types were encountered. Sediment samples in Hells Hole Canyon and Evacuation Creek were low in feldspar and high in dolomite and clay, while Southam Canyon and Asphalt Wash samples were high in feldspar and low in dolomite.

c. Interpretation and Conclusions

In order to derive meaningful conclusions from the two-year baseline monitoring program, it was necessary to perform a series of steps condensing and summarizing the massive volume of data generated during the program. The first step involved calculating the mean, standard deviation, maximum, and minimum values for each parameter at each station in every time period (baseflow, lower basin runoff, and upper basin snowmelt). Where similarities between stations justified consolidation, data were summarized still further. The comparability of reported data was determined by F tests using the analysis-of-variance (ANOVA) approach. This method was selected because it incorporates not only the number of samples and mean values but also the variance between samples. The method employed also offers the advantage of allowing easy comparison between baseline and future conditions, and at the same time permits incorporation of future data into the baseline record. This is possible because three values--number of samples, mean, and standard deviation--completely define the distribution formed by the samples and thus comparisons and updates can be performed without having to refer to the raw data and perform lengthy calculations.

Interpretations of the data and the data reduction process are described below for each major drainage within the study area.

White River--Analysis of Data Comparability: Two major steps were followed in summarizing the data collected at each station over seven flow periods (baseflow, 1974-1975; 1975-1976 and late 1976; lower basin runoff, 1975 and 1976; and upper basin snowmelt, 1976 and 1976). The first step was to compare mean,

TABLE II - 6

SUMMARY OF SECOND YEAR STREAMBED MINERALOGY AT THE
WHITE RIVER GAUGE SITES
(S-1, S-3, S-4, S-11)

Mineral	<u>Number of Samples</u>	<u>Mean %</u>	<u>Standard Deviation</u>	<u>Maximum %</u>	<u>Minimum %</u>
Quartz	4	49	5	53	43
Potassium feldspar	4	7	4	13	6
Plagioclase feldspar	4	7	2	9	5
Calcite	4	10	1	10	9
Dolomite	4	9	2	11	7
Analcime	4	1	1	2	0
Chlorite	4	0	0	0	0
Kaolinite	4	3	1	3	2
Illite	4	3	1	3	2
Montmorillonite	4	1	1	2	1
Mixed layer clay minerals	4	6	1	7	5

TABLE II - 7

SUMMARY OF SECOND YEAR STREAMBED MINERALOGY AT THE
EVACUATION CREEK GAUGE SITES
(S-7, S-6, S-2, S-15, S-8)

Mineral	<u>Number of Samples</u>	<u>Mean %</u>	<u>Standard Deviation</u>	<u>Maximum %</u>	<u>Minimum %</u>
Quartz	5	28	14	43	10
Potassium feldspar	5	7	1	9	5
Plagioclase feldspar	5	9	4	16	7
Calcite	5	14	6	24	9
Dolomite	5	13	3	17	10
Analcime	5	3	2	5	1
Chlorite	5	1	1	2	0
Kaolinite	5	3	2	4	0
Illite	5	5	4	11	2
Montmorillonite	5	0	1	1	0
Mixed layer clay minerals	5	8	3	13	7

SOURCE: VTN, 1977

TABLE II - 8

SUMMARY OF SECOND YEAR STREAMBED MINERALOGY AT THE
SOUTHAM CANYON RIVER GAUGE SITES
(S-9, S-13)

<u>Mineral</u>	<u>Number of Samples</u>	<u>Mean %</u>	<u>Standard Deviation</u>	<u>Maximum %</u>	<u>Minimum %</u>
Quartz	2	24	1	25	23
Potassium feldspar	2	7	3	9	5
Plagioclase feldspar	2	19	0	19	19
Calcite	2	14	6	9	8
Dolomite	2	5	1	5	4
Analclime	2	9	3	11	7
Chlorite	2	1	1	1	0
Kaolinite	2	1	0	1	1
Illite	2	2	1	3	2
Montmorillonite	2	8	6	12	4
Mixed layer clay minerals	2	5	1	5	4

SOURCE: VTN, 1977

TABLE II - 9

SUMMARY OF SECOND YEAR STREAMBED MINERALOGY AT THE
HELLS HOLE CANYON RIVER GAUGE SITE
(S-5)

<u>Mineral</u>	<u>Number of Samples</u>	<u>%</u>
Quartz	1	22
Potassium feldspar	1	5
Plagioclase feldspar	1	5
Calcite	1	14
Dolomite	1	23
Analcime	1	3
Chlorite	1	0
Kaolinite	1	7
Illite	1	7
Montmorillonite	1	0
Mixed layer clay minerals	1	12

SOURCE: VTN, 1977

TABLE II - 10

SUMMARY OF SECOND YEAR STREAMBED MINERALOGY AT THE
 ASPHALT WASH RIVER GAUGE SITE
 (S-10, S-12)

<u>Mineral</u>	<u>Number of Samples</u>	<u>Mean %</u>	<u>Standard Deviation</u>	<u>Maximum %</u>	<u>Minimum %</u>
Quartz	2	21	21	22	19
Potassium feldspar	2	5	1	7	5
Plagioclase feldspar	2	17	0	17	17
Calcite	2	12	1	13	11
Dolomite	2	6	2	7	4
Analcime	2	7	1	7	6
Chlorite	2	1	1	1	0
Kaolinite	2	1	1	1	0
Illite	2	4	1	4	3
Montmorillonite	2	2	3	4	0
Mixed layer clay minerals	2	11	4	14	8

SOURCE: VTN, 1977

standard deviation, maximum, and minimum values between stations in each period at the 90% significance level.

The basic hypothesis developed at the beginning of the monitoring program was that the data collected at all four White River stations (S-1, S-3, S-4, and S-11) would be generally the same between stations. This hypothesis was supported by the monitoring results, discussed below.

During Period 1 (baseflow 1974-1975) only 2 of 60 tests on individual constituents failed (e.g., had significantly different values at the 90% confidence level). Fluoride failed, probably because of limitations in the testing process at levels close to detection limits. Chemical oxygen demand failed, and was attributed to changes in biological activity. In Period 2 (lower basin runoff 1975), copper, cadmium, and lead failed out of 61 tests; copper because of one high value; cadmium and lead because of very low values. The only tests failing of 60 total during Period 3 (upper basin snowmelt 1975) were fecal coliforms and fecal strep, because of variations in biological activity. During Period 4 (baseflow 1975-1976) three tests out of 65 failed; nitrate because of low levels, and boron and cobalt because of high values. In Period 5 (lower basin runoff 1976), dissolved organic carbon, gross beta, and nickel failed out of 60 total tests because of unusual values. Temperature and sulfate failed out of 37 tests during Period 6 (upper basin snowmelt 1976). In Period 7 (baseflow, late 1976) fluoride again failed out of 43 tests because reported levels were near detection limits.

In general, therefore, failures were attributed to one or two anomalous values or levels near detection levels close to the limits of the analytical procedures. The success ratios were strikingly high for all seven periods, falling below a 5% failure rate throughout the duration of the monitoring program. This confirmed the hypothesis that data collected from S-1, S-3, S-4, and S-11 would be generally the same between stations.

The second step in the analysis involved comparison of data from parallel streamflow periods (i.e., the three baseflow periods [periods 1, 4, and 7], lower basin runoff [periods 2 and 5], upper basin runoff [periods 3 and 6]) to determine if the results were similar enough to allow for development of combined data sets for each streamflow period. Failure rates were 39 of 64 tests during baseflow; 14 of 54 tests during lower basin runoff; and 10 of 38 tests during upper basin runoff.

Although the relatively high failure rates showed that parallel periods were not similar over the duration of the monitoring program, this difference is attributed to the hydrologic system's response to differences in climatic conditions rather

than changes in the hydrologic system; therefore, it is appropriate to combine the results of similar periods from different years so that natural climatic variations are included in the baseline record. That the system has not changed is supported by the similarity of the stiff diagrams for parallel periods shown on Figure II-59. The diagrams illustrate the relative proportion of major cations (potassium, calcium, and magnesium) and major anions (chloride, carbonate, and sulfate). Although there is some variation from year to year, there is a definite similarity in the basic configuration for parallel streamflow periods. As illustrated, upper basin snowmelt is obviously similar and distinct from other periods. Lower basin runoff is similar to baseflow except for a higher percentage of sodium and sulfate, which represent the dominant ions in Evacuation Creek (and presumably in the other lower basin streams, also).

The water quality data from which these figures were derived are summarized on Table II-11.

Interrelationships Between Water Quality Parameters: Surface water characteristics typically follow certain patterns between mutually-interdependent parameters including flow and specific conductance, specific conductance and dissolved solids, and dissolved solids and several related cations and anions.

Flow and specific conductance are usually inversely related, i.e., specific conductance decreases when flow increases. This relationship is illustrated in Figure II-60, which represents a curve fitted to the combined data for each flow period. The parallel lines indicate the 80% prediction interval (i.e., if data points were plotted, 80% would fall within these boundaries); therefore, a narrow band indicates a good data correlation or "fit", while a wide interval shows a poorer fit. As shown in Figure II-60, the prediction interval is relatively narrow, indicating a close correlation in the data. It is especially significant that the baseflow and upper basin snowmelt curves are closely aligned, as would be expected, since flow is derived from the same source area during both periods. The apparent discontinuity during lower basin runoff reflects the influence of lower basin drainages such as Evacuation Creek, which has a considerably different specific conductance.

In contrast, specific conductance and dissolved solids are directly related and not dependent on time of year or flow variations (see Figure II-61). The narrowness of the prediction interval (here and on all later graphs a 90% interval) again indicates a good data fit.

Figures II-62 and II-63 illustrate the relationships between total dissolved solids and calcium, magnesium, sodium, bicarbonate, sulfate, and chloride. All six constituents showed a fairly good data correlation, particularly for magnesium and

S-1,3,4,11 BASEFLOW 8/1/74 - 2/25/75



-2%

S-1,3,4,11 7/26/75 - 2/15/76



-2%

S-1,3,11 7/1/76 - 9/30/76



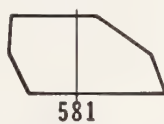
0.0%

S-1,3,4,11 LOWER BASIN RUNOFF 2/26/75 - 4/27/75



+2%

S-1,3,4,11 2/16/76 - 4/30/76



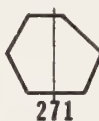
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S-1,3,4,11 UPPER BASIN RUNOFF 4/28/75 - 7/25/75



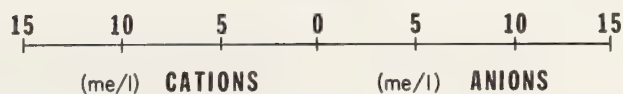
-2%

S-1,3,4,11 5/1/76 - 6/30/76



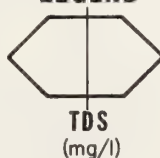
-1%

SCALE



LEGEND

(me/l) Na+K
(me/l) Ca
(me/l) Mg



Cl (me/l)
HCO₃ (me/l)
SO₄ (me/l)

00% = PERCENT BY WHICH
ANIONS EXCEED CATIONS

**BALANCE AND DISTRIBUTION OF MAJOR IONS IN SURFACE WATER
WHITE RIVER, UTAH**

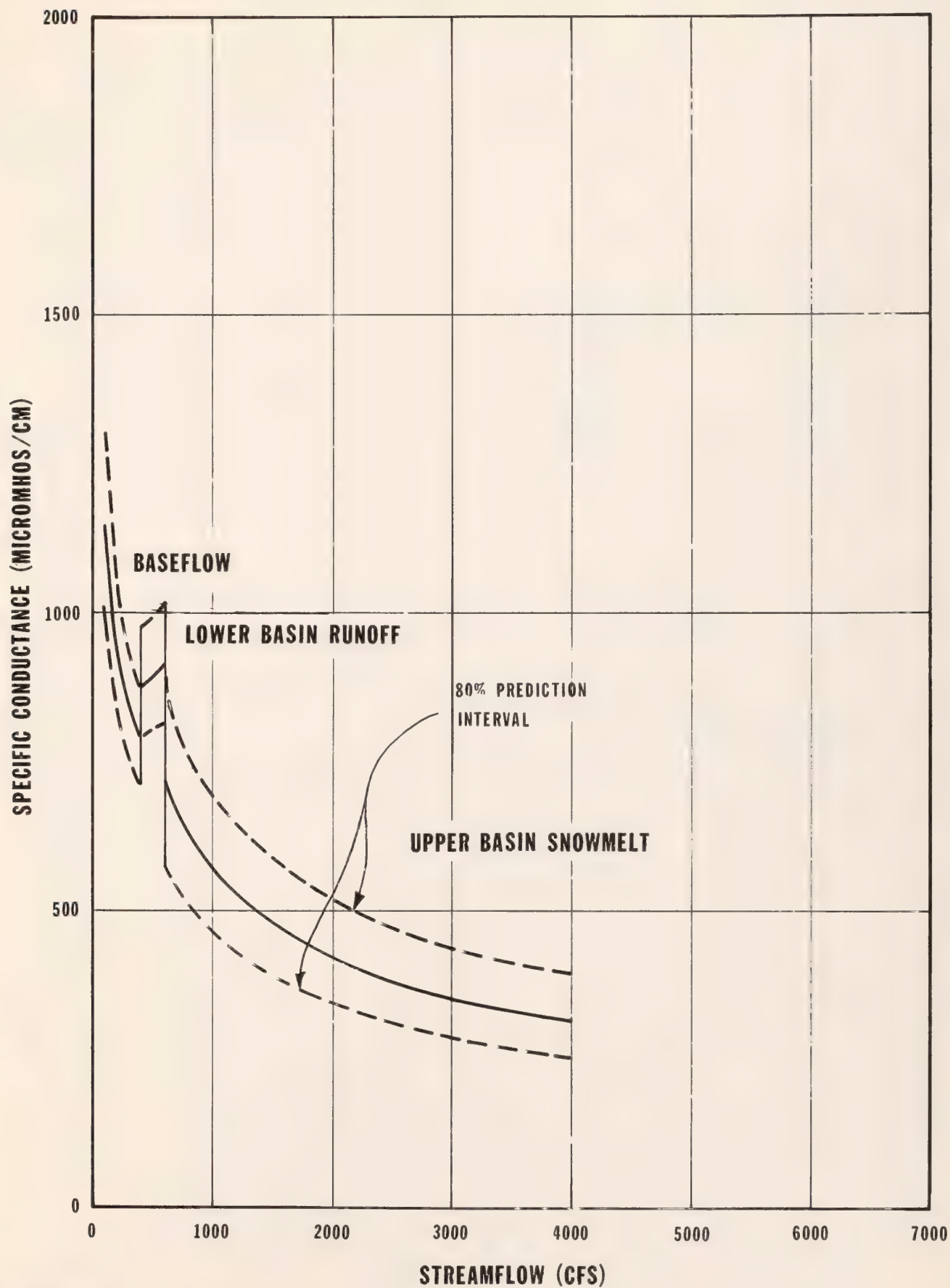


TABLE II—11
SUMMARY OF WHITE RIVER WATER QUALITY
(OCTOBER 1974 TO SEPTEMBER 1976)

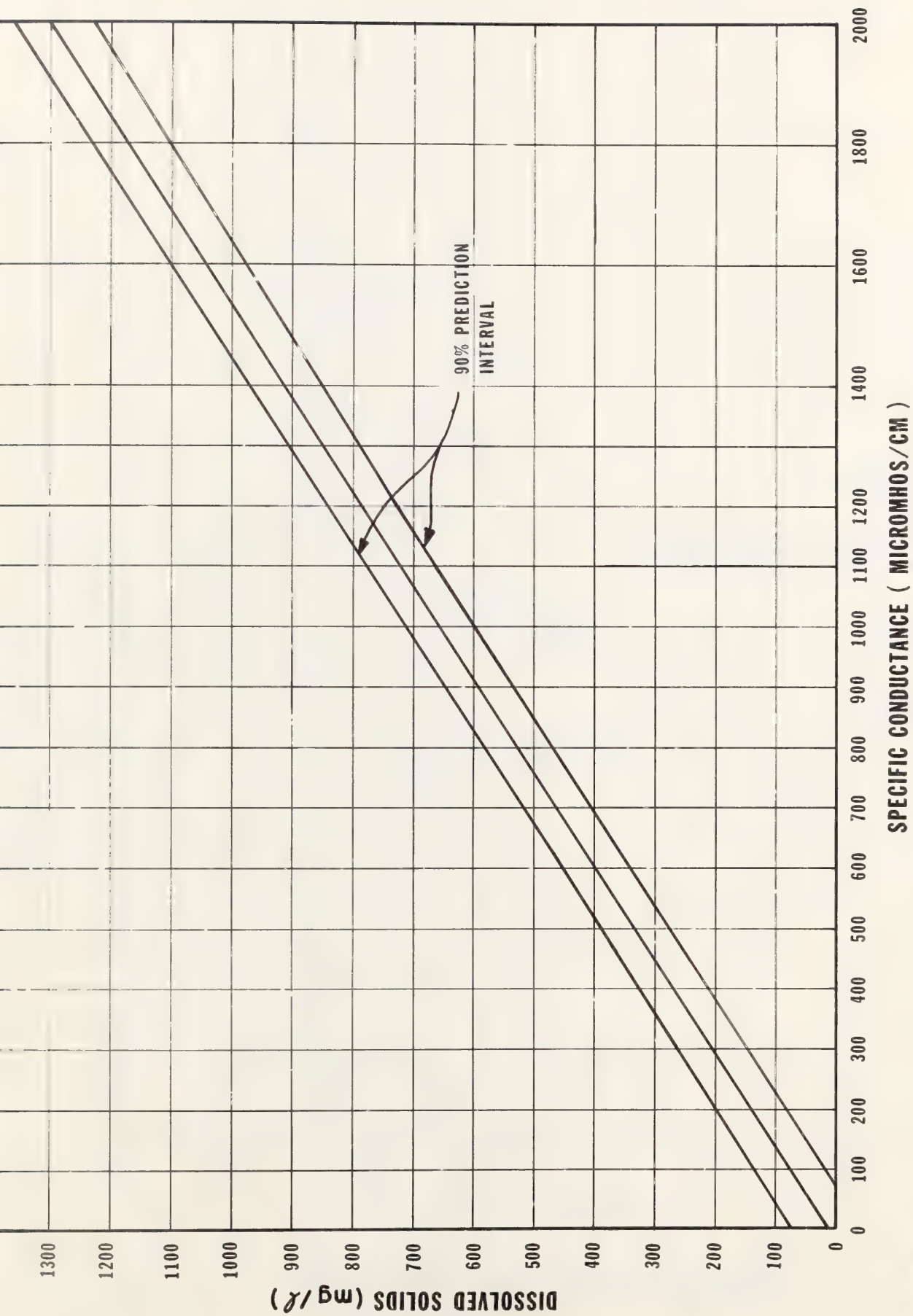
	Baseflow				Lower Basin Runoff				Upper Basin Runoff							
	Number of Samples	Mean	Standard Deviation	Maximum	Minimum	Number of Samples	Mean	Standard Deviation	Maximum	Minimum	Number of Samples	Mean	Standard Deviation	Maximum	Minimum	
GENERAL CHARACTERISTICS	Alkalinity (mg/l)	69	199	16	242	147	27	177	58	221	144	32	134	22	204	107
	Dissolved Solids (mg/l)	81	526	51	717	449	25	588	44	676	513	29	293	74	536	212
	Hardness (mg/l)	89	289	31	460	240	27	340	25	340	220	32	280	39	280	140
	Non-carbonate Hardness (mg/l)	89	90	12	260	61	27	103	11	120	79	32	100	19	100	26
	Oil and Grease (mg/l)	70	4	21	180	0	30	2	3	9	0	21	2	2	9	0
	pH (units)	64	8.1	4	8.8	7.0	24	8.2	6	9.4	6.8	28	7.8	6	8.8	6.5
	Specific Conductance (umhos)	91	813	121	1650	625	27	874	71	1010	700	32	473	132	810	320
	Streamflow (CFS)	81	385	76	578	202	28	485	108	853	263	25	1740	721	544	2721
	Temperature (°C)	38	10.0	8.8	28.5	(-5)	30	6.3	5.1	14.0	(-10)	32	15.5	3.9	22.5	7.9
	MAJOR CATIONS	Calcium (mg/l)	89	70	10	120	61	27	70	5	76	56	32	46	9	67
Magnesium (mg/l)		89	27	4	39	22	27	30	3	35	20	32	16	5	28	11
Potassium (mg/l)		91	2.3	9	6.1	9	26	2.3	1.4	4.0	2.0	32	1.7	4	3.0	1.3
Sodium (mg/l)		89	71	18	180	34	27	82	10	110	65	32	32	14	75	17
SAR		89	34	4	4.4	8	27	2.1	2	2.7	1.7	30	1.0	4	2.0	2
MAJOR ANIONS	% Sodium	89	34	4	5.4	18	27	3.7	2	4.2	3.3	32	2.6	4	3.7	2.1
	Srionium	32	946	151	1300	660	14	915	109	1000	700	12	453	210	750	400
	Bicarbonate (mg/l)	89	241	20	295	175	27	237	21	269	175	32	164	24	215	125
	Carbonate (mg/l)	84	2976	1	7	0	27	1	4	22	0	31	0	0	1	0
	Chloride (mg/l)	88	40	12	120	25	27	41	6	58	25	32	15.5	8.5	42	8.3
MAJOR ANIONS	Sulfate (mg/l)	89	176	21	230	140	27	209	20	260	180	32	88	39	190	59
	Sulfide (mg/l)	76	2.5	4	7.6	0	24	2	4	1.3	0	21	1	2	2	0
	Fluoride (mg/l)	89	3	1	1.0	1	27	3	1	3	0	32	2	1	4	2
	Bromide (mg/l)	76	2	2	9	0	25	1	1	2	1	21	0.285	1	2	0
	BIOCHEMICAL CONSTITUENTS	Carbon Dioxide (mg/l)	61	3.9	5.8	42.0	6	19	2.9	1.9	5.6	6	28	12.1	20.4	96
Dissolved Oxygen (mg/l)		40	8.0	1.8	15.0	6.4	23	9.1	1.5	11.7	6.2	19	7.0	1.9	9.7	2.4
BOD (mg/l)		27	9	5	14.0	0	0	—	—	—	—	3	14	9	1	8
COD (mg/l)		75	9	6	36	0	23	2.3	9	45	5	21	60	52	200	8
SOC (mg/l)		2	4.4	9	50	3.7	4	8	1.3	—	2	0	—	—	—	—
TOC (mg/l)		18	5.3	2.9	12.0	2.1	6	6.4	3.5	—	—	4	27.5	19.0	48	8.8
TIC (mg/l)		4	4.3	11	57	32	0	—	—	—	—	0	—	—	—	—
DOC (mg/l)		11	6.8	3.9	14.0	2.5	6	5.8	3.4	12	3.0	8	5.8	1.5	8.6	4.4
Total Coliforms (count/100 ml)		34	31	44	175	0	8	143	119	320	12	22	201	225	760	0
Fecal Coliforms (count/100 ml)		34	30	25	80	0	8	24	65	24	2	22	197	319	1395	0
BIOCHEMICAL CONSTITUENTS	Chlorophyll A (ug/l)	33	1.9	1.9	8.80	0.0	8	3.60	2.15	7.10	1.30	9	7.11	4.46	13.0	1.8
	Chlorophyll B (ug/l)	34	2.0	3.1	15.0	0.0	8	1.91	2.21	5.60	1.91	9	4.67	4.17	12.0	2
	Chlorophyll B (count/100 ml)	34	84	171	680	2	8	83	81	180	4	22	189	172	680	0
	Fecal Strept (count/100 ml)	34	84	171	680	2	8	83	81	180	4	22	189	172	680	0
	MACRO NUTRIENTS	Ammonia (mg/l)	82	0.3	0.4	19	0.0	23	0.5	0.6	29	0.0	29	0.2	0.2	0.4
Nitrite (mg/l)		82	0.01585	0.1	0.2	0.0	23	0.1	0.2	0.4	0.0	29	0.1	0.1	0.3	0.0
Nitrate (mg/l)		82	12	18	110	0.0	24	14	14	52	0.0	29	16	31	38	0.1
Kjeldahl Nitrogen (mg/l)		82	38	24	110	0.3	25	76	35	140	26	29	7.6	175	211	3.2
Orthophosphate (mg/l)		89	0.2	0.9	8.7	0.0	27	0.1	0.1	0.4	0.0	32	0.2	0.2	0.6	0.0
Total Phosphorus (mg/l)		82	0.3	0.3	25	0.0	24	0.1	0.4	16	0.1	29	17	17	63	0.0
MICRO NUTRIENTS	Boron (ug/l)	64	81	26	190	40	21	75	15	120	60	22	45	17	70	0
	Copper (ug/l)	51	6	22	160	0	19	41	82	340	2	11	4	4	60	1
	Iron (ug/l)	57	28	41	270	0	19	33	21	80	10	20	38	25	90	0
	Manganese (ug/l)	56	4	8	20	0	18	9	7	30	0	20	2	6	10	0
	Zinc (ug/l)	45	21	34	180	0	19	12	16	60	0	11	4	5	20	0
	Molybdenum (ug/l)	52	3	3	10	0	19	18	45	150	1	11	2	1	4	1
	Cobalt (ug/l)	45	0.887	1	< 2	0	13	—	—	1	0	11	18	1	1	0
	Silica (ug/l)	89	13	2	17	11	25	12	8	13.0	8.6	32	12.8	1.8	17	11
TRACE METALS	Aluminum (ug/l)	55	17	16	80	0	19	30	25	90	0	19	30	19	80	0
	Barium (ug/l)	33	48	91	140	0	14	38	38	100	0	11	27	48	130	0
	Beryllium (ug/l)	25	—	—	20	0	13	—	—	10	0	4	0	0	0	0
	Bismuth (ug/l)	19	—	—	< 15	3	6	—	—	< 17	< 4	3	—	—	< 2	< 2
	Cadmium (ug/l)	46	0	1	1	0	20	1	1	2	0	11	0	45	1	0
	Chromium (ug/l)	40	2	8	20	0	14	2	5	10	0	11	0	0	0	0
	Gallium (ug/l)	19	—	—	< 6	< 2	6	—	—	< 6	< 2	3	0	0	0	0
	Germanium (ug/l)	19	—	—	< 20	< 4	6	—	—	< 20	< 5	3	—	—	< 5	< 2
	Lead (ug/l)	46	2	2	7	0	13	4	10	37	4	11	1	1	4	0
	Lithium (ug/l)	47	12	18	110	0	19	22	11	30	0	11	5	9	20	0
	Mercury (ug/l)	42	0.7	13	42	0	19	0	0	1	0	11	0.3	1	2	0
	Nickel (ug/l)	46	5	5	16	0	14	2	4	1	0	11	3	2	6	0
	Selenium (ug/l)	43	1	1	43	0	15	2	1	2	1	11	1	1	6	0
	Silver (ug/l)	12	0	1	1	0	8	—	—	< 2	0	4	0	0	0	0
	Tin (ug/l)	19	—	—	< 15	< 3	6	—	—	< 17	< 4	3	—	—	< 2	< 2
	Titanium (ug/l)	18	—	—	< 10	2	5	—	—	< 6	< 6	2	8	2	10	6
	Vanadium (ug/l)	46	1.6	17	10.0	0	14	1.4	6	2.0	3	11	1.1	7	2.0	0
	Zirconium (ug/l)	18	—	—	< 20	< 5	6	—	—	< 30	< 7	3	—	—	< 3	< 3

TABLE II-11 (continued)

	Baseline					Lower Basin Runoff					Upper Basin Runoff				
	Number of Samples	Mean	Standard Deviation	Maximum	Minimum	Number of Samples	Mean	Standard Deviation	Maximum	Minimum	Number of Samples	Mean	Standard Deviation	Maximum	Minimum
TRACE NON-METALS	Arsenic (ug/l)	2	1	4	0	15	8	9	2	0	19	1	8	2	0
	Cyanide (mg/l)	0	0	0	0	15	00	01	01	00	19	00	01	01	00
	MBAS (mg/l)	02	06	0	0	7	0	0	0	0	0	—	—	—	—
	Phenols (ug/l)	3	3	14	0	25	4	3	8	1	29	4	3	14	0
	Pesticides (ug/l)	0	0	0	0	6	0	0	0	0	0	—	—	—	—
RADIOACTIVE CONSTITUENTS	Herbicides (ug/l)	0	0	0	0	6	0	0	0	0	0	—	—	—	—
	Cesium 137 (PC/l)	0	0	<10	<10	4	0	0	10	0	1	0	0	<10	0
	Gross Alpha (ug/l)	110	62	280	85	8	145	86	350	71	8	69	34	120	37
	Gross Beta (SR-90) (PC/l)	46	41	250	16	14	5	2	250	23	10	35	10	49	23
	Gross Beta (CS-137) (PC/l)	49	30	130	37	15	64	57	84	29	10	43	13	69	28



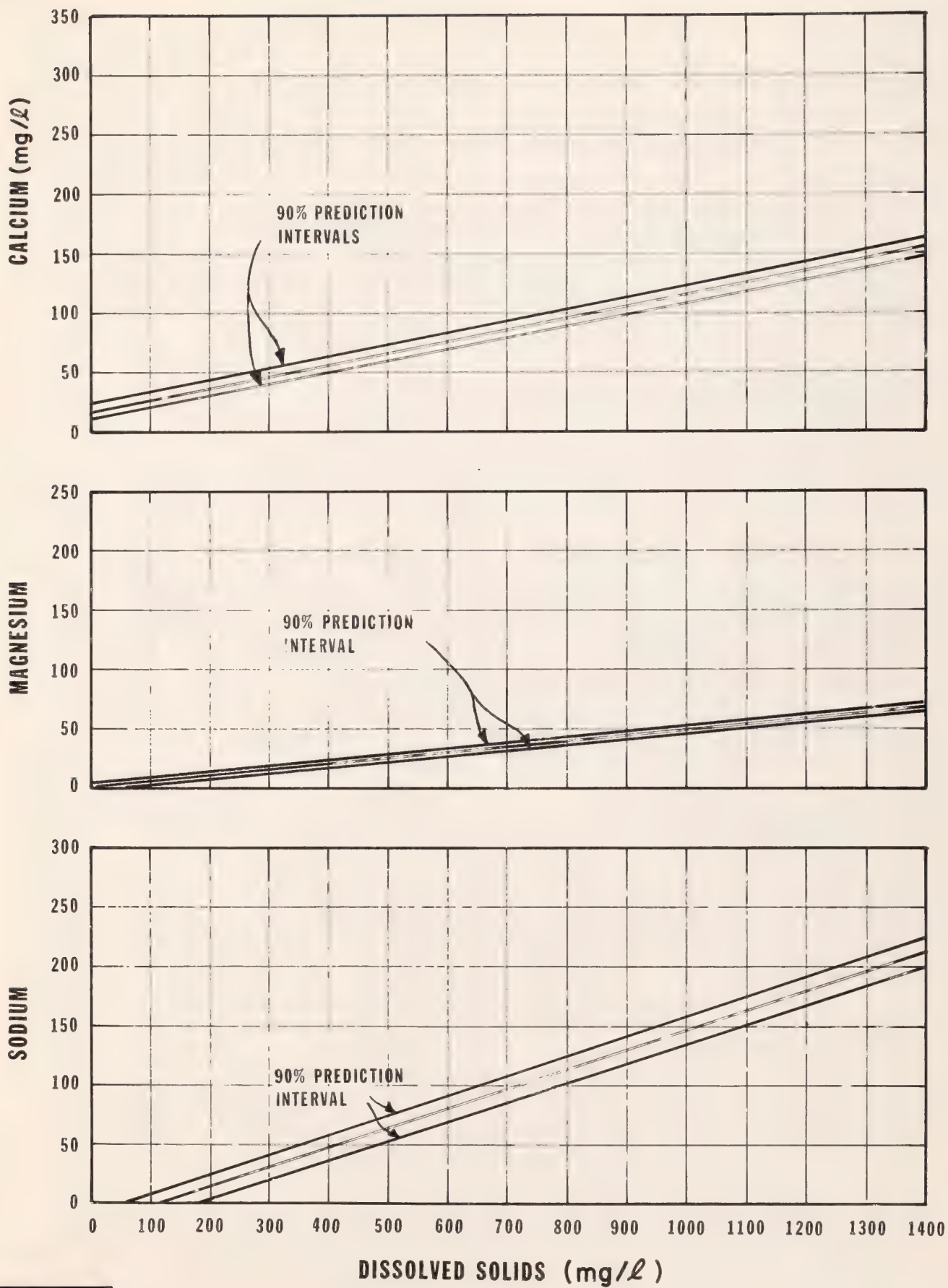
STREAMFLOW - SPECIFIC CONDUCTANCE RELATION



SPECIFIC CONDUCTANCE - DISSOLVED SOLIDS RELATION
WHITE RIVER

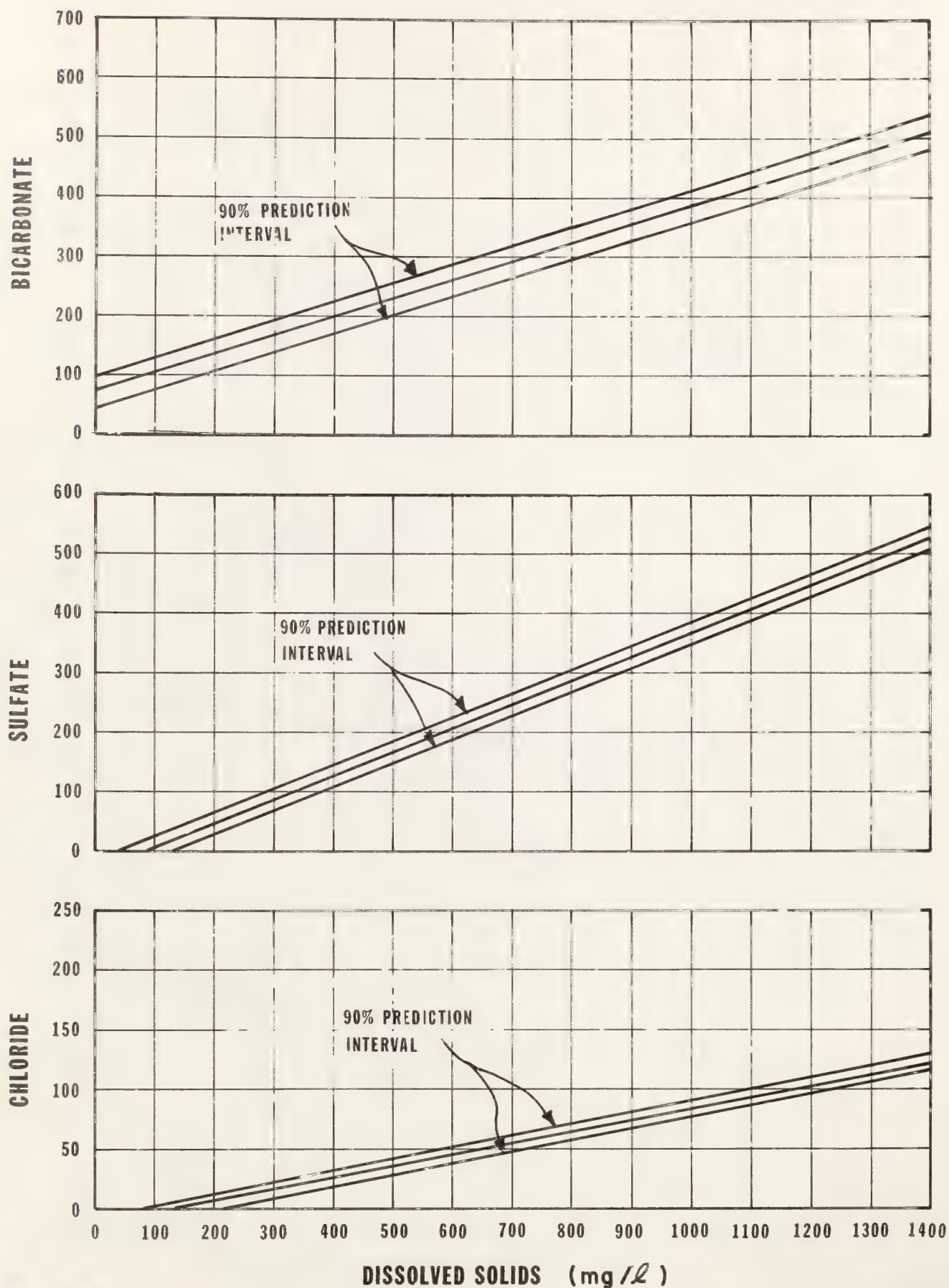
FIGURE II-61





**DISSOLVED SOLIDS - CALCIUM, MAGNESIUM AND SODIUM RELATION
WHITE RIVER**





**DISSOLVED SOLIDS - BICARBONATE, SULFATE AND CHLORIDE RELATION
WHITE RIVER**



chloride. The variability of each constituent in relation to streamflow is indicated by the steepness of the slope (i.e., sodium and sulfate express the greatest variability, and magnesium and chloride showed the greatest stability).

Therefore, by monitoring flow it is possible to approximate specific conductance, dissolved solids concentration, and concentrations of calcium, magnesium, sodium, bicarbonate, sulfate, and chloride at these stations on the White River. By monitoring dissolved solids concentration, a fairly accurate estimate of calcium, magnesium, sodium, bicarbonate, sulfate, and chloride concentrations in the White River can be made.

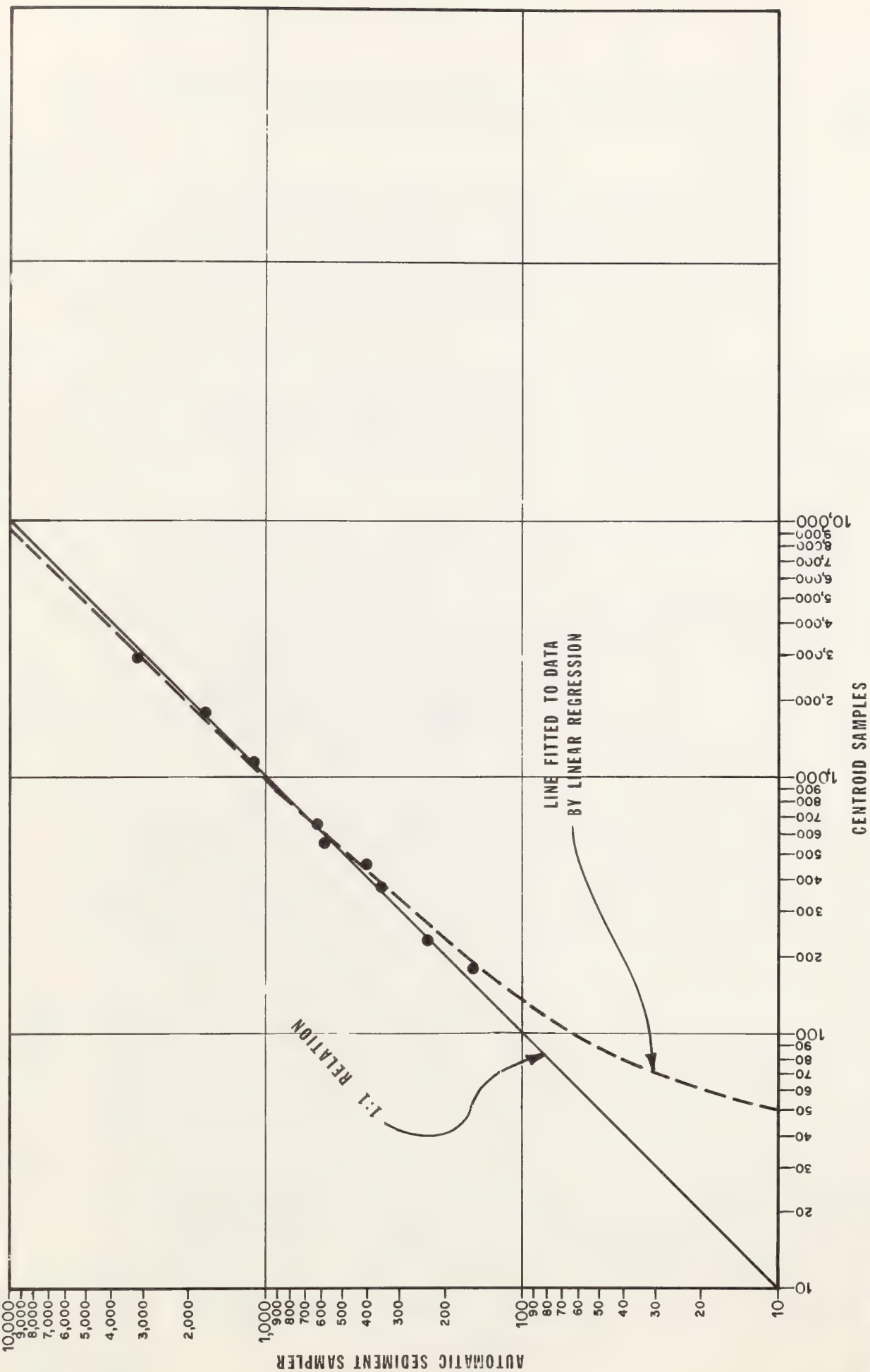
Suspended sediment sampling was increased during the second year with the addition of an automatic sampler at S-11. The good correlation between data collected by the automatic sampler and the normal centroid samples is illustrated by Figure II-64, indicating that the automatic sampler results are nearly identical to centroid samples.

The relationship between suspended sediment and streamflow is clarified by the additional data available during the second year of monitoring (see figures II-27 and II-28). During baseflow and lower basin runoff, sediment concentrations are usually low, but are occasionally high because of intermittent increases in sediment caused by soil-laden surface runoff. A more distinct relationship appears during upper basin runoff (see Figure II-65). As flow increases sediment concentrations also increase very rapidly but reach a maximum before peak flow. During the falling stage sediment concentrations are much lower than during the rising stage.

Evacuation Creek--Analysis of Data Comparability: The same basic process used for the White River was followed in analyzing data collected from Evacuation Creek; however, specific steps varied in response to differences in the data base. For example, mean/standard deviation tables similar to those prepared for the White River (Table II-12) were performed for five time periods: baseflow in 1974-1975, baseflow in 1975-1976, lower basin runoff in 1975 and in 1976, and upper basin snowmelt in 1975.

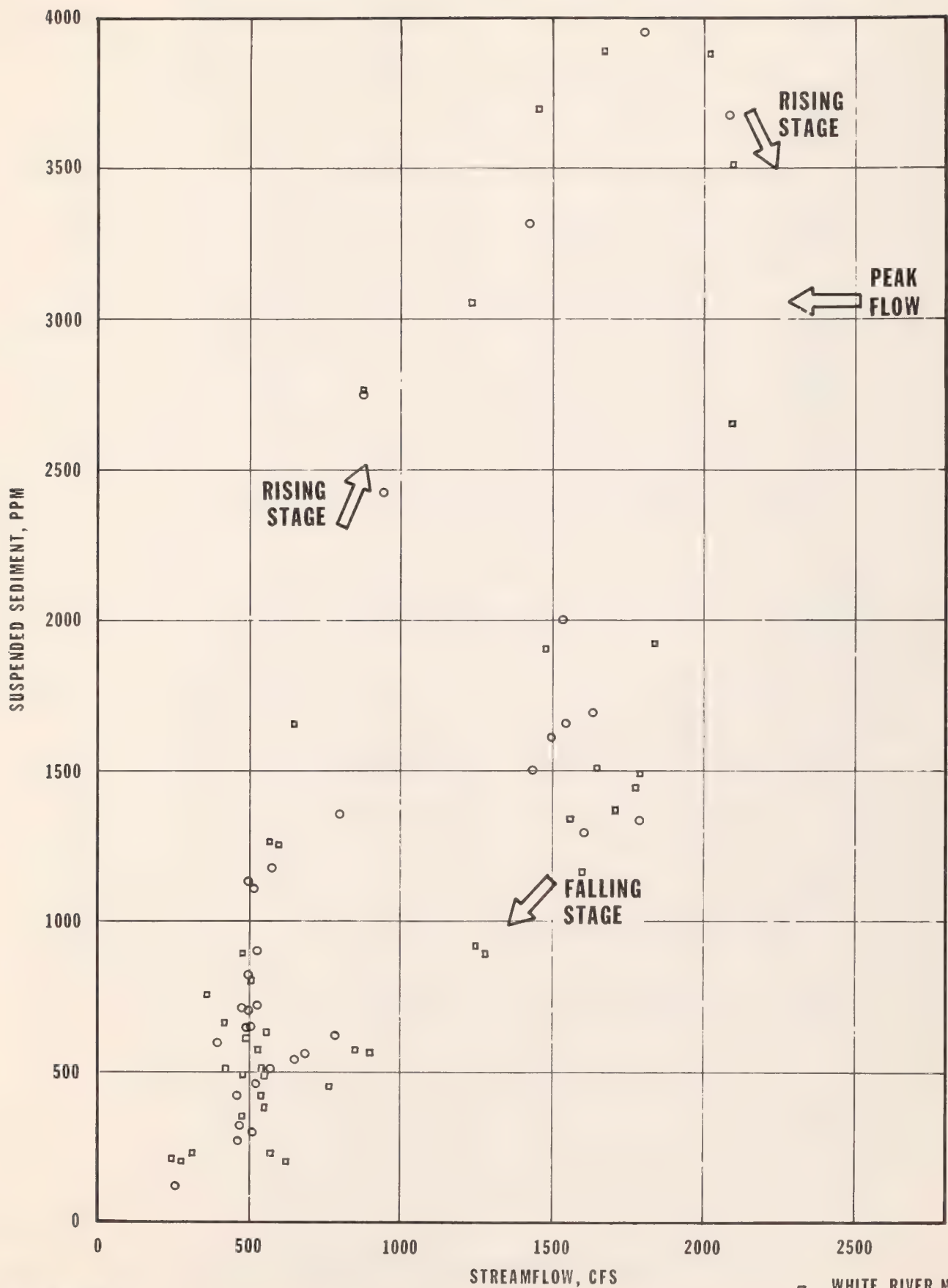
Unlike the White River data, however, it was not possible to summarize all stations within each time period because of the difference between stations S-2 and S-6 caused by the aquifer interaction. Consequently, data were first summarized between time periods at each station using the ANOVA testing procedure described in the preceding section.

At Station S-2 near the mouth of Evacuation Creek, 4 of 56 highflow tests failed (oil and grease, sulfide, orthophosphate and total organic carbon). Oil and grease and sulfide failed due to low concentrations, while orthophosphate and TOC failed for unknown reasons. During baseflow 18 of 64 tests failed;



RELATION BETWEEN CENTROID SEDIMENT SAMPLES AND AUTOMATIC SEDIMENT SAMPLES
WHITE RIVER





**STREAMFLOW VS. SUSPENDED SEDIMENT CYCLE
WHITE RIVER**

□ WHITE RIVER NEAR WATSON
○ WHITE RIVER
BELOW ASPHALT WASH



TABLE 11-12
SUMMARY OF EVACUATION CREEK WATER QUALITY
(AUGUST 1974 TO SEPTEMBER 1976)

TABLE II-12 (continued)

	Baseline										Hydroline									
	Station E-3					Station E-7					Station E-2					Station E-8				
	Number of Samples	Mean	Maximum	Minimum	Number of Samples	Mean	Maximum	Minimum	Number of Samples	Mean	Maximum	Minimum	Number of Samples	Mean	Maximum	Minimum	Number of Samples	Mean	Maximum	Minimum
Asbestos	17	2	3	0	15	3	5	0	8	1	2	2	9	1	2	0	8	1	2	0
Chalcide	15	00	00	00	15	00	00	00	8	00	01	00	9	002	004	00	9	005	002	000
Phenols	20	4	25	0	21	3	9	0	12	3	11	0	14	3	2	0	14	5.0	28	0
Plastics	0	—	—	—	0	—	—	—	0	—	—	—	1	0	0	0	1	—	—	—
Hydrocarbons	0	—	—	—	0	—	—	—	0	—	—	—	1	0	0	0	1	—	—	—
PC-1	2	0	<1.0	<1.0	3	0	<1.0	<1.0	2	0	<1.0	<1.0	1	0	0	0	1	0	<1.0	0
PC-2	12	0	20	<1.0	10	0	140	<1.0	8	0	<1.0	<1.0	5	74	25	50	7	0	61	18
PC-3	11	20	55	<1.0	10	41	140	<1.0	7	16	25	<1.0	7	0	0	<1.0	7	0	0	0
Gross Beta <LS 121	6	33	66	16	10	51	170	18	6	21	50	15	7	0	0	<1.0	7	0	29	7

however, temperature was the only general characteristic to fail and potassium was the only major ion to fail. The other failures included 4 of 6 macronutrients, 2 of 8 micronutrients, 5 of 12 trace metals, 1 of 4 trace non-metals and 4 of 11 biochemical constituents.

At Station S-6 near Watson, 5 of 57 tests failed during high-flow (temperature, chromium, lead, mercury, and cyanide), while 6 of 57 tests failed during baseflow (temperature, fluoride, bromide, molybdenum, silica, and total organic carbon). With the exception of temperature during both periods and silica and TOC during baseflow, the failures resulted from low concentration levels, the causes of the other failures.

At Station S-7 below Park Canyon, 8 of 55 baseflow tests failed: manganese, aluminum, nickel, and phenols because of low levels; and temperature, potassium, ammonia, and orthophosphate for unknown causes.

Although ANOVA failure rates were generally higher for the Evacuation Creek stations, summarization of the data by station still appears to be justified. This approach is especially supported by the Stiff diagrams shown on figures II-66 and II-67. As indicated on the diagrams, sodium and sulfate are the dominant ions as in the case of the White River.

Interrelationships Between Water Quality Parameters: In general, relationships between the parameters discussed for the White River exhibited a less direct correlation in Evacuation Creek. No curve is included for streamflow versus conductance for that reason. Specific conductance versus dissolved solids and specific conductance versus major cations and anions are shown on figures II-68 through II-70. It should be noted that in all cases the 90% prediction interval is broader than that shown for the White River. The closest correlation is indicated for sodium and sulfate, while the broad prediction intervals shown for calcium and bicarbonate demonstrate the least data correlation. During the 2 years of record, sodium and sulfate showed the greatest variability (degree of change through time) as indicated by the steepness of the slope, and chloride and bicarbonate displaying the least.

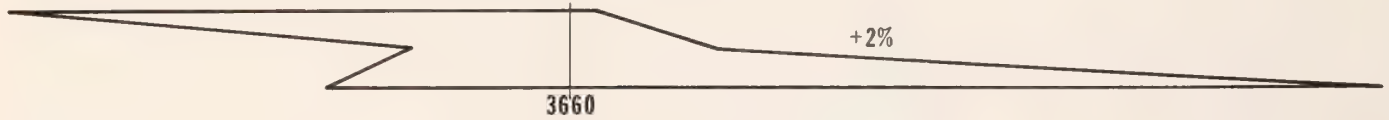
The interaction of ground water from the bird's nest aquifer and surface water in Evacuation Creek is clearly shown by comparing the chemistry of both systems. In aquatic environments such as surface water, where oxygen is present, oxidation occurs, i.e., the combination of oxygen with available electrons causes a deficiency of electrons, which in turn attracts donation of electrons from other elements (e.g., Fe^{+2} becomes $\text{Fe}^{+3} + 3\text{e}^-$; S becomes $\text{S}^{+4} + 4\text{e}^-$, etc.).

In environments isolated from oxygen, such as is commonly found in aquifers, the absence of oxidizing agents causes the opposite

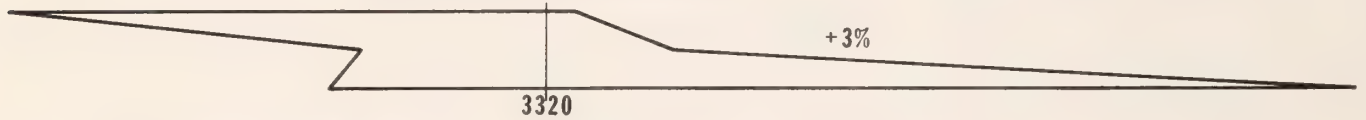
S-2 EVACUATION CREEK NEAR MOUTH 8/1/74 - 2/28/75



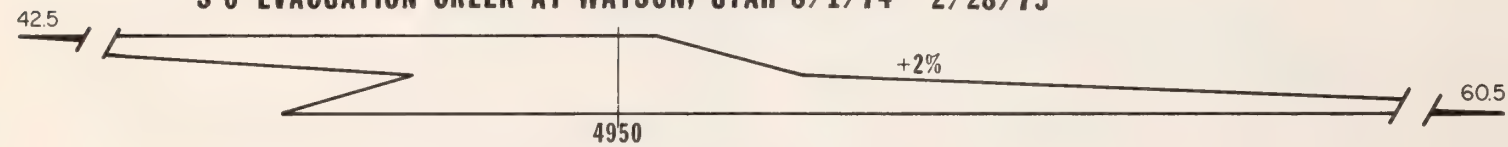
S-2 8/1/75 - 2/23/76



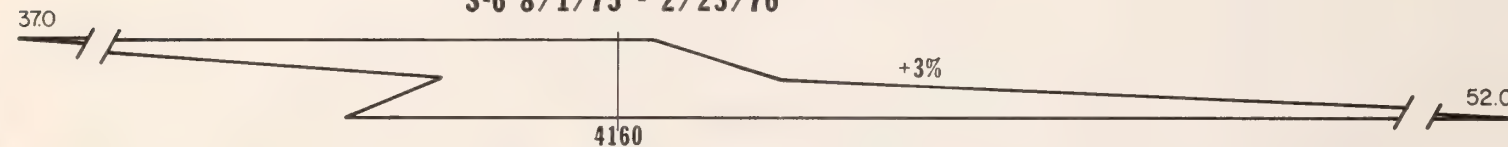
S-2 6/3/76 - 9/30/76



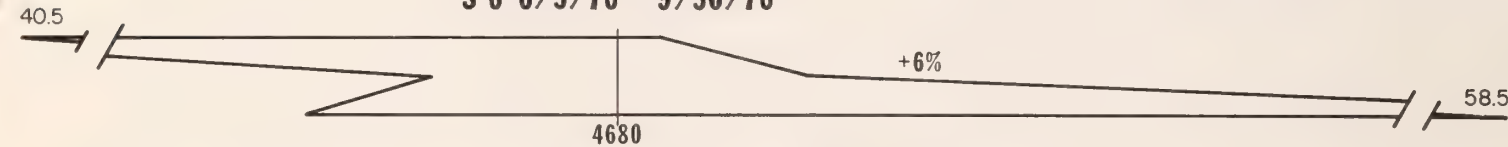
S-6 EVACUATION CREEK AT WATSON, UTAH 8/1/74 - 2/28/75



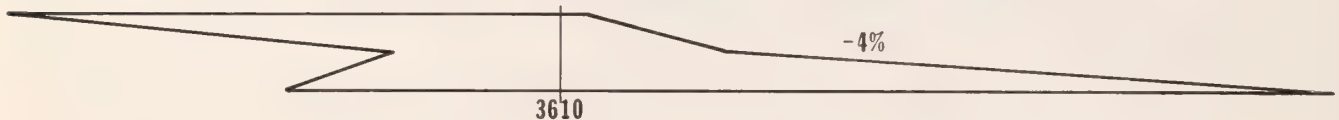
S-6 8/1/75 - 2/23/76



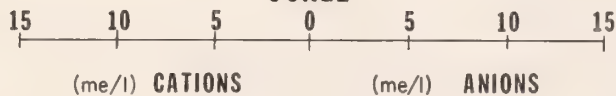
S-6 6/3/76 - 9/30/76



S-7 EVACUATION CREEK BELOW PARK CANYON 8/1/74 - 2/28/75

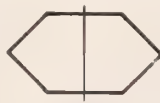


SCALE



LEGEND

(me/l) Na + K
(me/l) Ca
(me/l) Mg



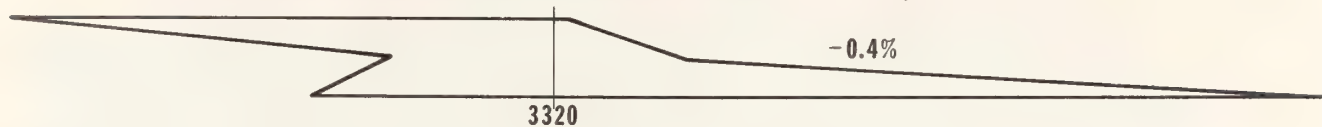
Cl (me/l)
HCO₃ (me/l)
SO₄ (me/l)

00% = PERCENT BY WHICH
ANIONS EXCEED CATIONS

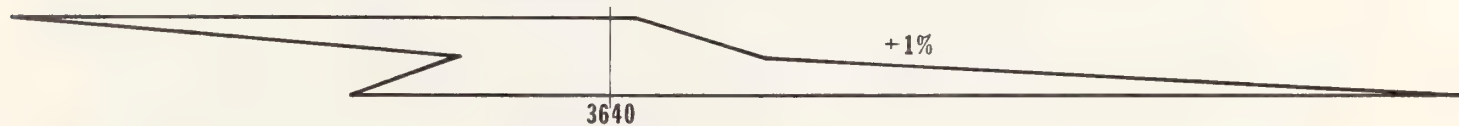


BALANCE AND DISTRIBUTION OF MAJOR IONS IN SURFACE WATER BASE FLOW PERIOD

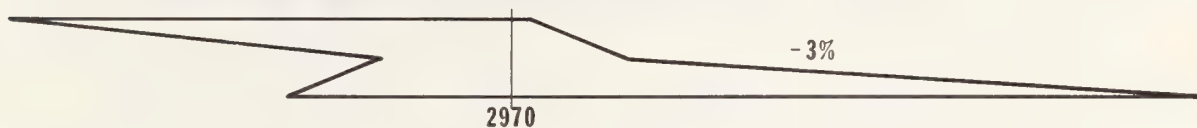
S-2 EVACUATION CREEK NEAR MOUTH 3/1/75 - 7/31/75



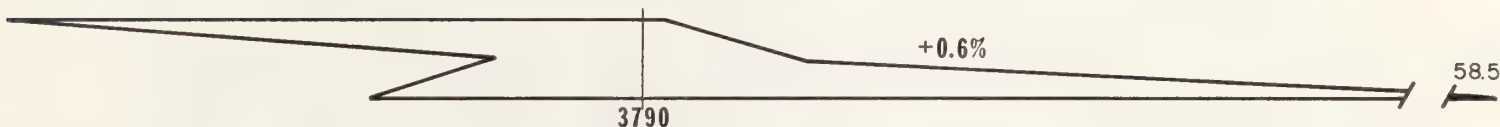
S-2 2/24/76 - 6/2/76



S-6 EVACUATION CREEK AT WATSON, UTAH 3/1/75 - 7/31/75



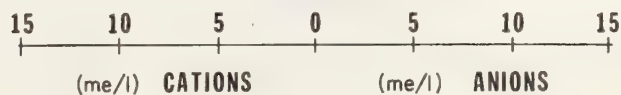
S-6 2/24/76 - 6/2/76



S-7 EVACUATION CREEK BELOW PARK CANYON 3/1/75 - 7/31/75

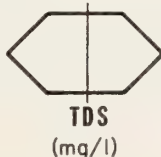


SCALE



LEGEND

(me/l) Na + K
(me/l) Ca
(me/l) Mg

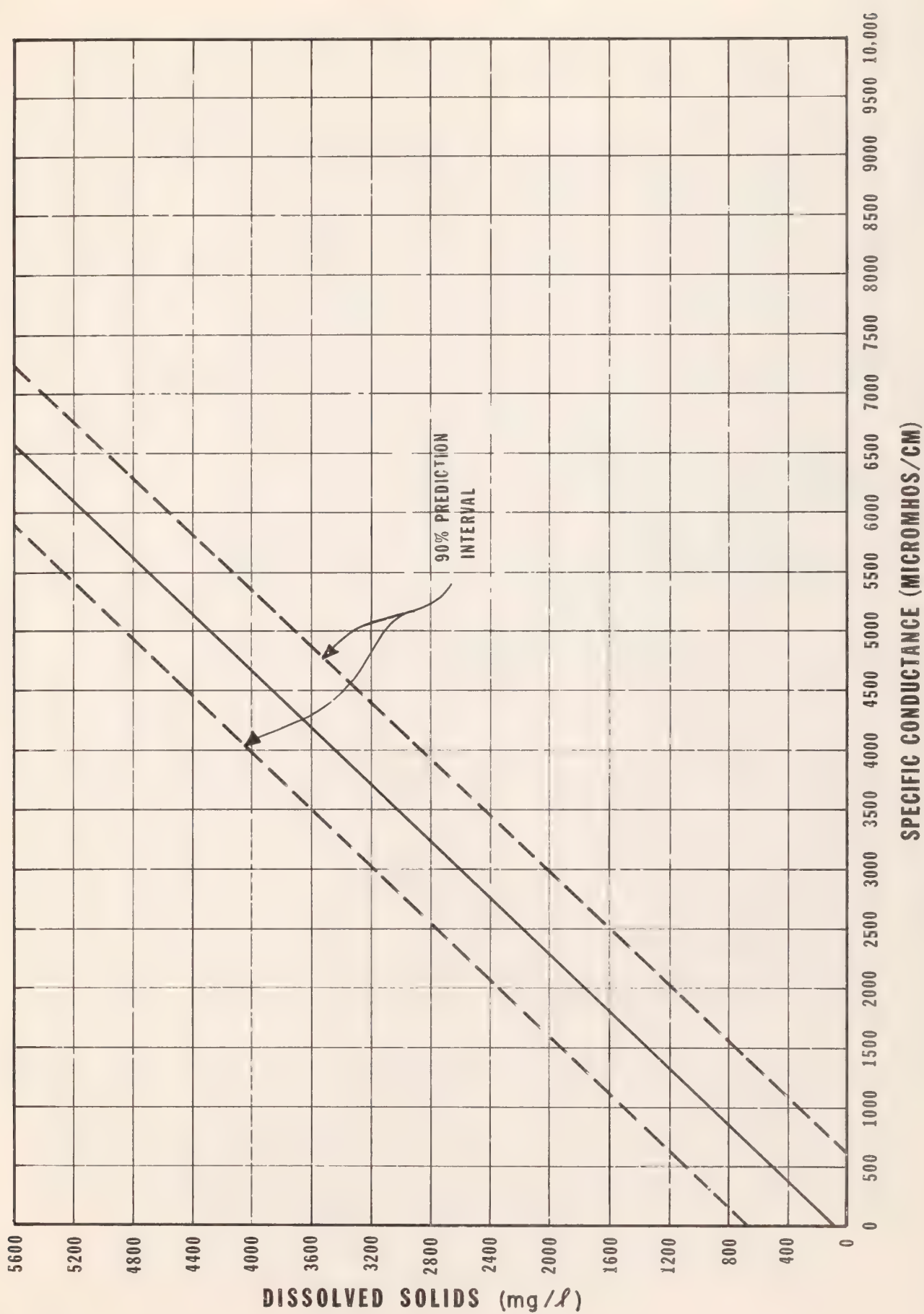


Cl (me/l)
HCO₃ (me/l)
SO₄ (me/l)

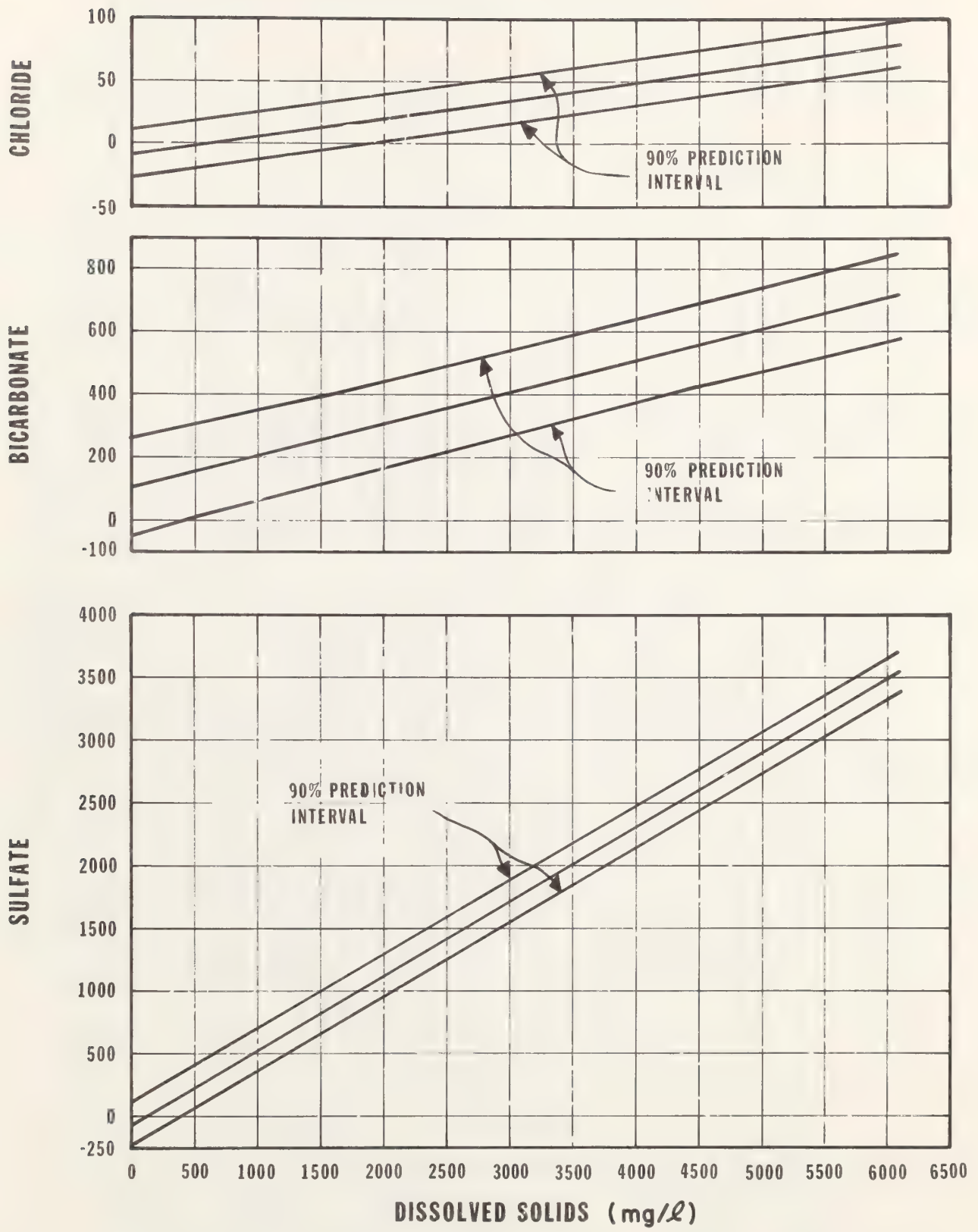
00% = PERCENT BY WHICH
ANIONS EXCEED CATIONS

**BALANCE AND DISTRIBUTION OF MAJOR IONS IN SURFACE WATER
HIGH FLOW PERIOD**



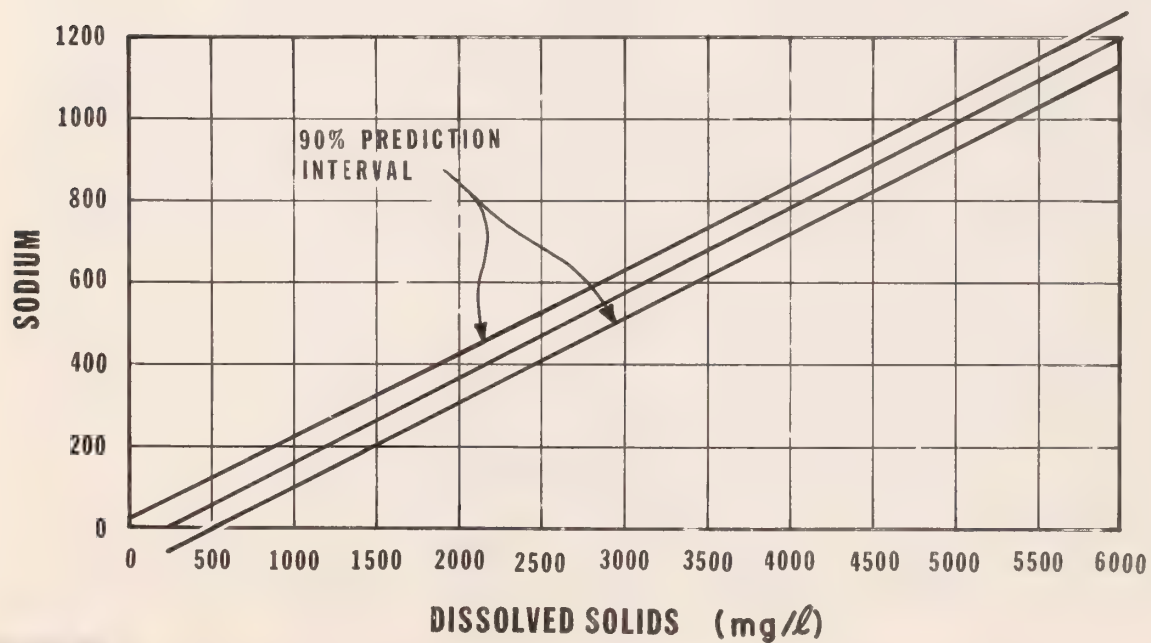
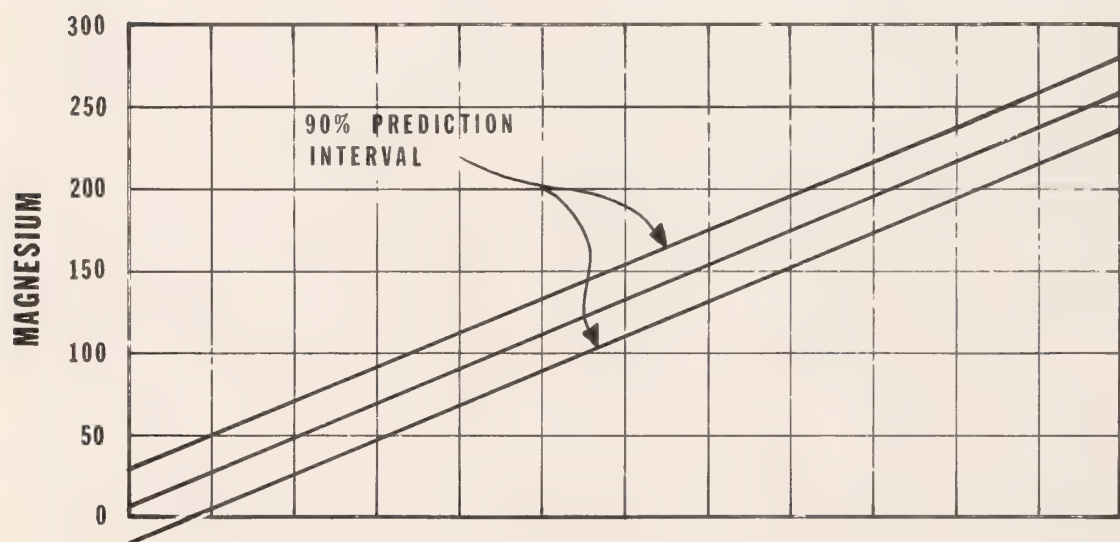
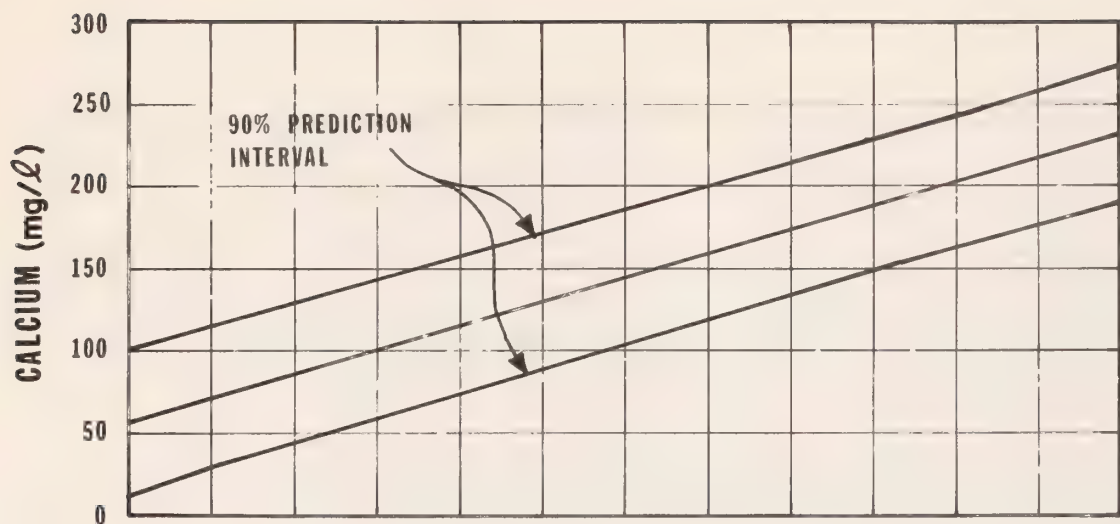


SPECIFIC CONDUCTANCE - DISSOLVED SOLIDS RELATIONSHIP



DISSOLVED SOLIDS - SULFATE, BICARBONATE AND CHLORIDE RELATION
EVACUATION CREEK





**DISSOLVED SOLIDS - SODIUM, MAGNESIUM AND CALCIUM RELATION
EVACUATION CREEK**



reaction to occur, i.e., a reduction process (sometimes carried on by bacteria) in which an abundance of electrons leads to their acceptance by elements such as sulfur and iron.

Further indication of a systems state is provided by the distribution of multivalent ions between reduced or oxidized states. For example, the reduced forms of sulfur (sulfide, S^{2-}) and nitrogen (ammonia, NH_4^+) will predominate in reduced systems, while sulfate (SO_4^{2-}) and nitrate (NO_3^-) will predominate in oxidized systems. This is borne out by an areal comparison of the bird's nest aquifer, showing higher sulfate-sulfide and nitrate-ammonia ratios in the northwest than in the southeast. This indicates a higher degree of oxidation, probably resulting from the influx of surface water from Evacuation Creek.

Similarly, comparison of Evacuation Creek above the aquifer interface at Station S-6 and further downstream at Station S-2 shows lower nitrate-ammonia and sulfate-sulfide ratios at S-2. This indicates probable seepage into the stream from the aquifer between the two stations.

Application of the Nernst Equation can be used to quantify these conclusions; however, samples from reduced systems apparently shift significantly towards the oxidized end of the spectrum after sampling and before reaching the laboratory. This shift is quite evident at some wells in the field by the formation of precipitates as the water flows from the sample pump during the collection of ground water samples from the bird's nest aquifer.

The Dry Washes: It was possible to draw only a few general conclusions regarding the three washes (Hells Hole Canyon, Southam Canyon, and Asphalt Wash) because of the variability of the data, as indicated by the means and standard deviations included on Table II-4. The primary conclusion about the water quality is that water in the washes is either from snowmelt or rainfall runoff and that snowmelt is typically lower in sediment than rainfall runoff; more detailed differentiation cannot be made with any degree of accuracy. In terms of precipitation quality, rainfall and snowmelt samples were nearly pure, with very low levels of dissolved solids (<10 mg/l) reported.

3. EVALUATION OF THE BASELINE PROGRAM

The data collected during the monitoring period were very comprehensive; the number of data alone are impressive, as is shown below.

<u>Program Element</u>	<u>Approximate Number of Values Collected</u>
Automatic stage, temperature, & conductance records	2,500,000
Streamflow measurements	670
Sediment samples	1,800
Water Quality Analyses (total individual constituents)	17,500
Precipitation measurements	840,000

Generally, the data were so comprehensive that trends such as the lower basin runoff effects on the White River, and the interaction between Evacuation Creek and the bird's nest aquifer could be quantified with only two years of data rather than the five or ten years of data that would normally be required. The disadvantage of the program is that two years was not long enough to observe long-term time trends; for instance, since streamflow during both years of the program was nearly average, the response of the water resource system to floods or long-term droughts could not be quantified. This does not appear to be a serious drawback, since the relationships developed in Interpretation and Conclusions are probably reliable enough to predict the response of the system to extreme climatic conditions.

Data of interest to other disciplines was also collected. Specifically, precipitation records were useful in interpreting plant growth trends, and the water chemistry data were helpful in analyzing the aquatic biology data. Conversely, information developed in the soils, meteorology, and vegetation programs was useful in interpreting the water resource data.

A record of pre-mining conditions was developed in the baseline monitoring program in anticipation of compliance monitoring for two basic types of alterations: short-term effects typified by high intensity, short duration events such as spills or inadvertent discharges; and long-term effects typified by low intensity, long duration events such as seepage from dams or tanks.

During short-term effects, the hydrosphere may be affected for hours or at the most, days, but the alterations are likely to be major during that time. These types of events will be monitored by the continuous records of flow, conductance, and temperature. The network is such that any affected water will pass by at least one of these stations.

During long-term events, the hydrosphere may be affected for months, if not years, but the alterations are likely to be subtle. The monthly water quality samples will be the best

method to monitor these changes. The primary constituents of interest will be the major anions and cations used to determine the character of the water in techniques like those outlined in "Interpretation and Conclusions". Additional constituents from the other categories should also be monitored if they are present in chemicals used or produced in the mining, retorting, or reclamation processes. Such chemicals are likely to include several of the macronutrients, most of the micronutrients and biochemical constituents, and a few of the trace metals, trace non-metals, and radioactive constituents. Again, any affected water will pass at least one station where periodic samples are being collected.

B. GROUND WATER RESOURCES

1. METHODOLOGY

The ground water hydrology of Tracts U-a and U-b and the vicinity was studied using data from aquifer wells, alluvial wells, and moisture monitoring wells. Four test drilling sites, designated P-1 through P-4, were selected for subsurface drilling to locate any aquifers present and to study the stratigraphy and oil shale properties beneath the tracts. The locations of the test sites are shown on Figure II-1. At each location, rotary air-drilling was used to collect continuous 8.9-cm (3.5-in.) core from the ground surface to a depth of about 122 m (400 ft) below the mahogany zone. At maximum intervals of 9.2 m (30 ft), the discharge fluids were measured for temperature, specific conductance, and flow quantities. A comprehensive suite of geophysical logs were run in these and subsequent drill holes for additional subsurface information concerning stratigraphy, ground water, and oil shale. These data consisted of gamma-ray, gamma-gamma density, neutron, neutron epithermal neutron, flow, temperature, caliper, SP, and resistivity logs.

Each of the four sites were developed as aquifer test sites with a pumping well and two up-dip observation wells at distances of about 15 m and 40 m (50 ft and 150 ft) from the pumping hole. One principal bedrock aquifer common to each of the four sites was found about 91.5 m (400 ft) above the mining zone. No additional aquifers were found below the principal bedrock aquifer. Fourteen additional wells were drilled and completed in this aquifer, both on and in the vicinity of the tracts, to determine ground water levels and quality.

Water-level sensing devices and punch-tape recorders, set to record at 15-minute intervals, were used for continuous monitoring of ground water levels at the three P-sites. Water levels were measured on a monthly schedule in all other wells with steel tape or electric probes. Ground water chemistry was determined by analyzing pumped water samples collected from all available wells a minimum of once every six months.

Aquifers were tested at three of the four sites during late summer and early fall 1975. The test results were used to determine aquifer properties, aquifer interrelationships, and ground water/surface water interrelationships. Additional data were obtained from detailed mapping of aquifer outcrops.

Five alluvial wells were installed in the Southam Canyon and Evacuation Creek drainages. Water levels were monitored routinely and samples were collected monthly for analysis when the alluvium contained water. Twelve additional alluvial wells were installed as directed by the AOSO in January 1976 and were included in the program for the second year of baseline data collection.

A program of up- and down-gradient moisture monitoring at proposed processed-shale disposal sites using specially constructed wells was presented to the AOSO in the Partial Exploration Plan. After approval, eight wells throughout Southam Canyon and Evacuation Creek drainages (proposed processed-shale disposal sites) were drilled and completed for studying moisture migration in the first few hundred meters of bedrock underlying the drainages. The methodology and results obtained from this program are discussed in the First Year Environmental Baseline Report (FYEBR). Although not outlined in the plan, the intent was to use a neutron-logging tool at periodic intervals to determine any redistribution (through time) of moisture in the first few hundred meters of material in the selected wells. The initial logging was done at the time of drilling in fall 1974, and the process was repeated in selected holes again in April, August, and December 1975.

Some differences were observed from logging run to logging run, but no discernible patterns emerged on either an areal basis or within any given borehole. Given the fracture patterns in the area, downward-moving moisture may or may not encounter a given well, or it could occur sporadically with depth in any given well. Also, each of the monitoring holes was completed with 11.4-cm (4.5-in.) ID steel casing set with cement in a 20.1-cm (7.9-in.) drill hole. The tool used had a net formation penetration of about 17.8 cm (7 in.). Residual drilling fluids in the borehole walls and differential drying of the cement could conceivably produce neutron log trace deflections totally unrelated to naturally occurring moisture migration. Every precaution was taken in attempting to reduce instrument and operator differences by calibrating the tool to field conditions at Birdwell's facility prior to each logging run and by using the same truck and operator. Even with these precautions the program continued to produce results that were uncorrelatable with known hydrologic events or uncorrelatable spatially, and therefore this element was deleted from the program.

2. SUMMARY OF RESULTS

a. Ground Water Occurrence

During the drilling program ground water was encountered at one location in the lower-most Uinta Formation during the drilling program and through the region in alluvial deposits along major stream courses and in the Green River, Wasatch, and Mesa Verde formations (Austin and Skogerboe 1970). The Green River Formation, especially its upper-most member, the Parachute Creek Member, contains the principal oil shale zone, and therefore most of the deeper wells were drilled to investigate this zone. Data from the deeper horizons on and around the tracts are available in geophysical logs of oil-test and gas-test wells.

Figure II-71 illustrates the potential water-bearing zones throughout the penetrated column. The log is generally representative of the region on and near the tracts. The principal aquifer (bird's nest aquifer) investigated as part of the baseline program occurs near the top of the Parachute Creek Member of the Green River Formation. The deep oil-test and gas-test wells used to locate the bird's nest aquifer penetrate beyond this aquifer and have a higher static head than would be expected by projecting gradients outward from the tracts. These wells, therefore, are not useful as indicators of the regional potentiometric surface in the bird's nest aquifer, although they provide information about the occurrence and physical characteristics of the principal aquifer.

The water-bearing potential of the geologic formations and their members was discussed in the FYEBR and therefore will not be discussed here. These data are summarized on Figure II-71.

b. Aquifers

The principal aquifer investigated in the tract area was the bird's nest zone, described by Cashion and Brown (1956) and redefined by Cashion (1974). This zone will be referred to as the bird's nest aquifer.

The bird's nest aquifer is in the upper part of the Parachute Creek Member of the Green River Formation. The base of the aquifer is about 131 m (430 ft) above the Mahogany Marker, and the top ranges from about 15 m to 38 m (50 ft to 125 ft) below the top of the Parachute Creek Member. Figure II-72

indicates the persistence of the aquifer for several kilometers around Tracts U-a and U-b. No additional water-bearing zones were encountered between the bird's nest aquifer and the Mahogany Marker.

The aquifer is characterized by nahcolite nodules set in marlstone overlain by a zone of thin, brittle shale beds, and by a fine-grained homogeneous sandstone from 4.6 m to 6.1 m (15 ft to 20 ft) thick called the horsebench sandstone (Cashion 1974). The two units, nahcolite zone and horsebench sandstone, define the bird's nest aquifer, which varies from 27.4 m to 62.5 m (90 ft to 205 ft) thick and averages about 35 m (115 ft) thick.

The bird's nest aquifer is exposed continuously from the White River southward for several kilometers along the banks or canyon walls of Evacuation Creek (Figure II-73). Springs and seepage from the aquifer are common throughout this area. The bird's nest aquifer is discussed more comprehensively in Quarterly Report No. 4 and in the FYEBR.

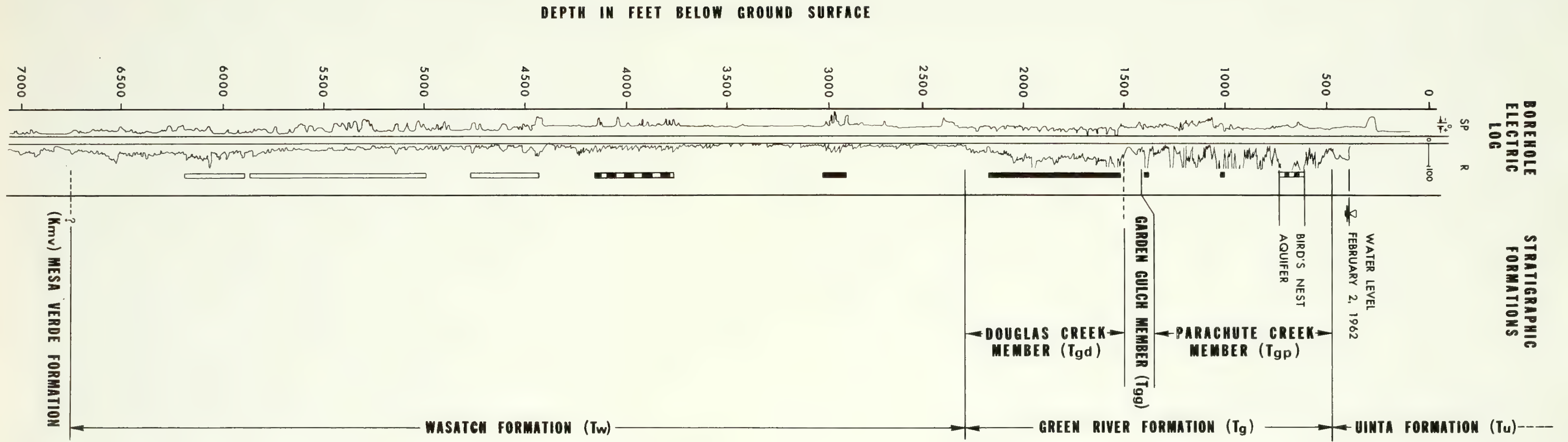
Only one project well has been completed in the Douglas Creek Member of the Green River Formation--well G-16A, far south of the tracts in the SE $\frac{1}{4}$ of Section 21 T11S, R25E. The well flows about 0.5 l/s (2 gpm) from a depth of 50 m (165 ft). Well P-4 at the western edge of Tract U-a is believed to be receiving water from the Douglas Creek Member from upward flow around an imperfect grout seal.

An aquifer in the lower-most Uinta Formation, or upper-most Parachute Creek Member, was encountered at the northwestern edge of Tract U-a. This is the only location at which the aquifer was encountered. In the following discussion the aquifer will be referred to as P-2 upper.

c. Hydraulic Properties

As determined from drilling, geophysical logging, and observation of outcrops, the bird's nest aquifer derives the vast majority of its porosity and permeability from solution cavities after nahcolite dissolution and fracturing. Flow rates from the aquifer during air-mist drilling of 26 drill holes penetrating the aquifer ranged from 0 to 44.1 l/s (700 gpm) and averaged nearly 1.9 l/s (30 gpm). The varied production rates are closely linked to the presence or absence of artesian head on the aquifer and to the degree of saturation in the water table portions of the aquifer. The aquifer is nearly dry in the southwestern portion of Tract U-b but is under about 76 m (250 ft) of artesian head in the northwestern edge of Tract U-a (Figure II-74).

T.D. 7033 FT.



LEGEND

ELECTRIC LOG OF BOREHOLE 13
SHOWING AQUIFER ZONES
(C, NE, SW, SEC. 32, T10S, R24E)

SP R

SP - SPONTANEOUS POTENTIAL
R - RESISTIVITY

POTENTIAL AQUIFER ZONE BASED UPON
ELECTRIC LOG RESPONSE.
OPEN WHERE WATER QUALITY INDICATED
TO BE SLIGHTLY SALINE TO SALINE.

TYPICAL BOREHOLE ELECTRIC LOG
OF ROCK FORMATIONS BENEATH THE SITE



LEGEND

- Tdr DUCHESNE RIVER FORMATION
- Tu UINTA FORMATION
- Tgr GREEN RIVER FORMATION - UNDIVIDED
- Tgp GREEN RIVER FORMATION - PARACHUTE CREEK MEMBER
- Tgd GREEN RIVER FORMATION - DOUGLAS CREEK MEMBER
- BIRDS NEST AQUIFER ZONE

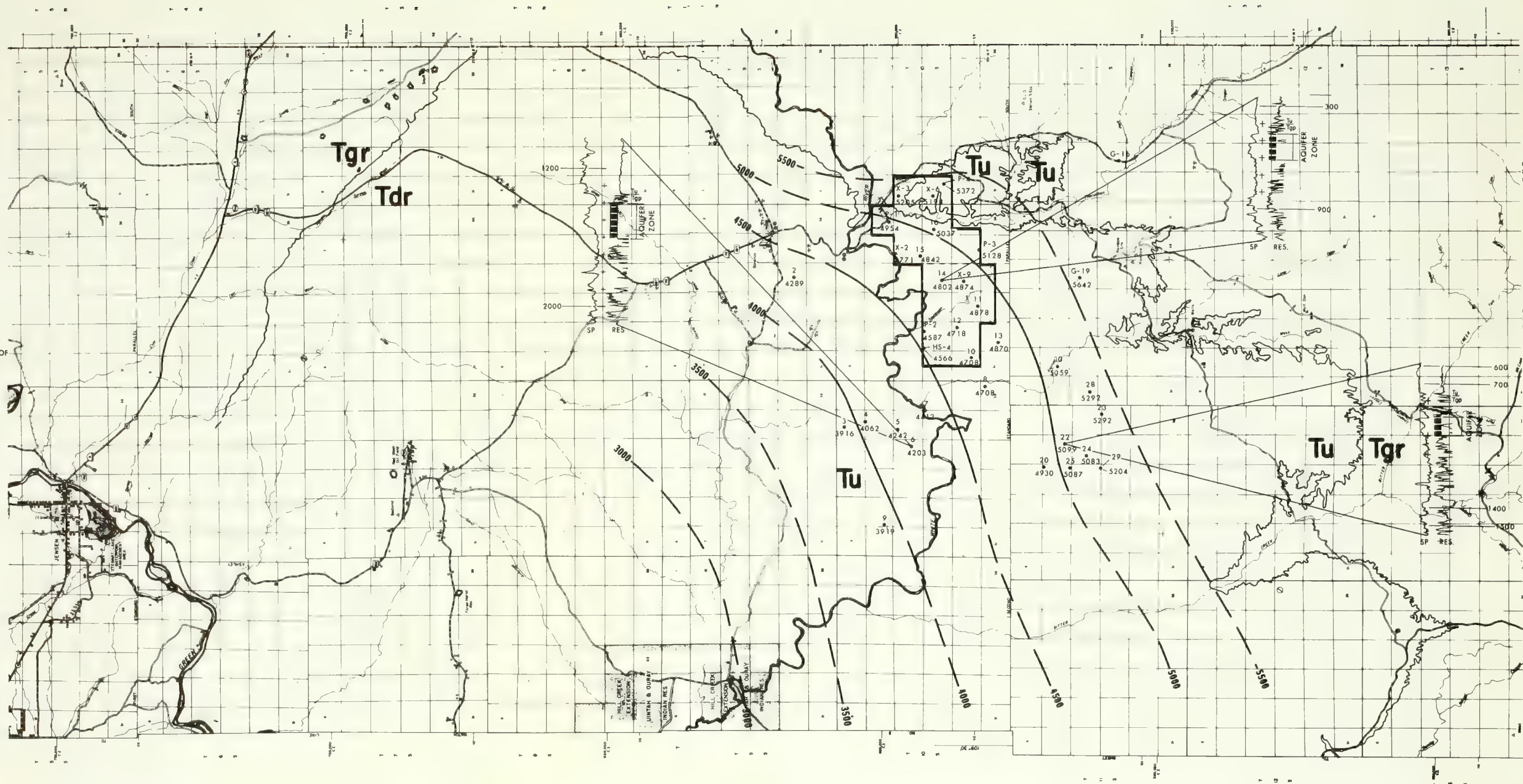
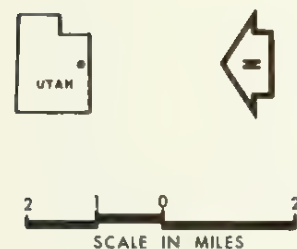
PROJECT WELL NUMBER - NUMBER KEYED TO LIST OF CORE HOLES AND EXPLORATORY HOLES ON TABLE IV-11

WELL LOCATION

ELEVATION AT THE TOP OF THE AQUIFER IN FEET

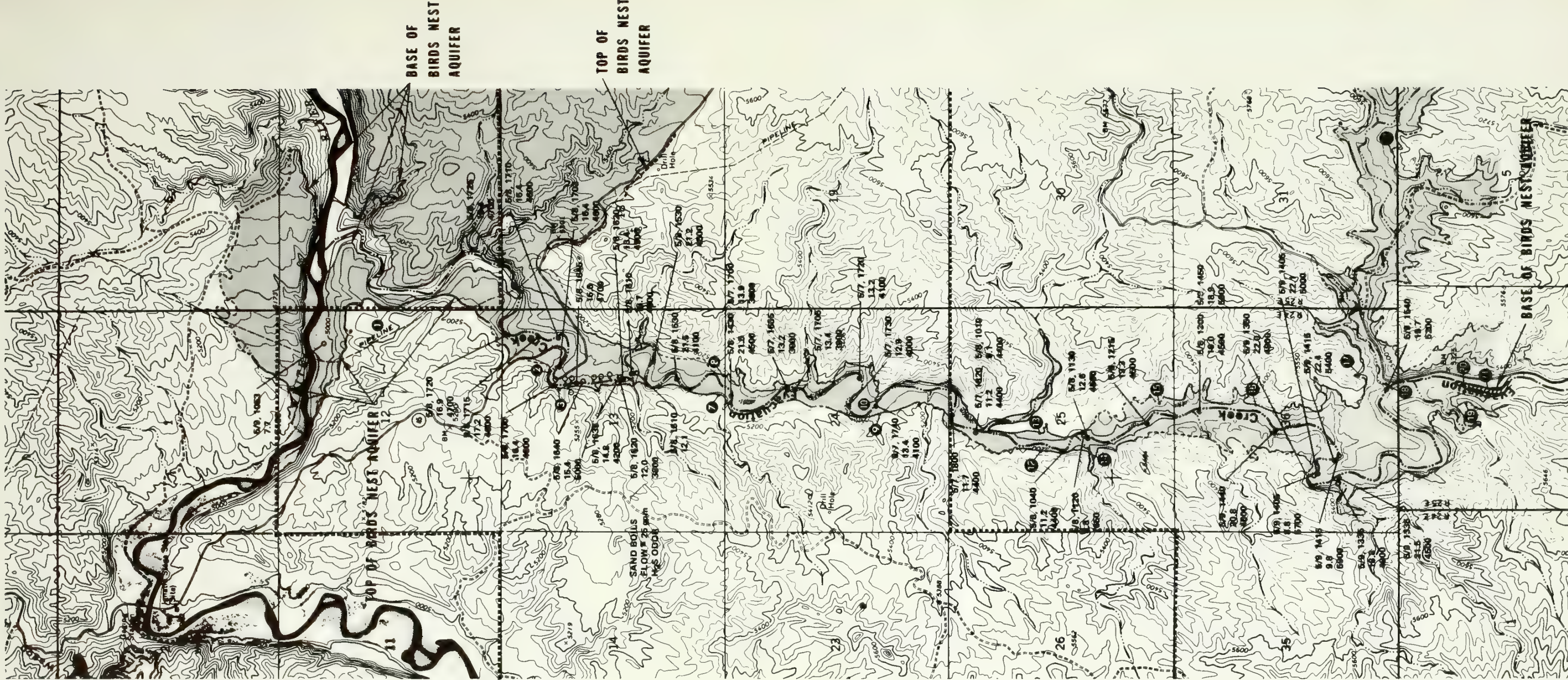
5000 CONTOURS ON THE TOP OF THE AQUIFER (DASHED WHERE INFERRED OR APPROXIMATE)

BOUNDARY OIL-SHALE TRACTS U₀ - U_b



STRUCTURAL CONTOURS ON THE TOP OF THE BIRDS NEST AQUIFER S.E. UINTA BASIN, UTAH

FIGURE II-72



LEGEND

SALT DEPOSITS WHICH INDICATE EVIDENCE OF GROUND WATER SEEPAGE

FLOWING SPRINGS

EPHEMERAL STREAM

DRY WASH

MEASUREMENTS OF TEMPERATURE AND SPECIFIC CONDUCTANCE

- EVACUATION CREEK (SHOWN EAST OF CREEK)
- SPRINGS FROM BIRDS NEST AQUIFER (SHOWN WEST OF CREEK)

DATE AND TIME

5/8, 1725
16.3 - TEMPERATURE, IN DEGREES CELSIUS
4700

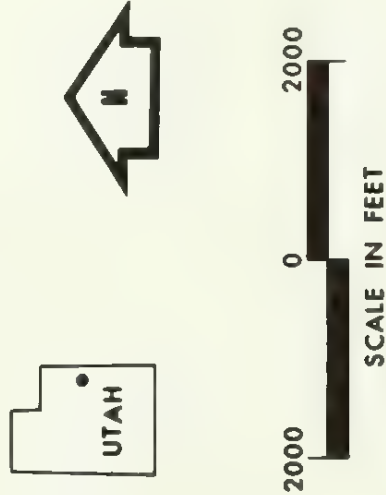
SPECIFIC CONDUCTANCE, IN MICRONHMS/CM

ELEVATION POINTS ALONG THE BIRDS NEST AQUIFER

ELEVATION POINT ON BIRDS NEST AQUIFER CONTACT, WITH STATION NUMBER

POINT	ELEVATION	LOCATION	DESCRIPTION
EP 1	5183.5	N602,270	E2,657,920
EP 2	5118.0	N598,645	E2,656,522
EP 3	5099.5	N598,410	E2,656,170
EP 4 (X-3)	5295.5	N598,774	E2,659,572
EP 5	5130.0	N596,862	E2,656,305
EP 6	5167.0	N596,780	E2,657,243
EP 7	5119.5	N594,550	E2,656,174
EP 8	5147.5	N594,500	E2,656,570
EP 9	5177.2	N590,755	E2,655,718
EP 10	5168.8	N590,842	E2,656,100
EP 11	5191.0	N588,335	E2,655,470
EP 12	5212.0	N585,954	E2,654,994
EP 13	5221.0	N585,965	E2,655,445
EP 14	5229.0	N585,795	E2,655,011
EP 15	5292.0	N584,152	E2,656,200
EP 16	5323.5	N581,905	E2,656,277
EP 17	5417.5	N579,522	E2,657,012
EP 18	5426.5	N578,560	E2,657,151
EP 19	5425.0	N577,080	E2,656,534
EP 20	5307.0	N577,010	E2,656,895
EP 21	5315.0	N576,500	E2,656,821
EP 22 ₁	5088.0	N601,028	E2,658,999
EP 22 ₂	5560.0	N578,805	E2,662,270
EP 23	5086.0	N603,405	E2,659,450

OIL SHALE TRACTS U-a & U-b BOUNDARIES



HYDROGEOLOGIC MAP OF EVACUATION CREEK, TRACTS U-a & U-b

LEGEND

(METERS)
15.2
50
(FEET)

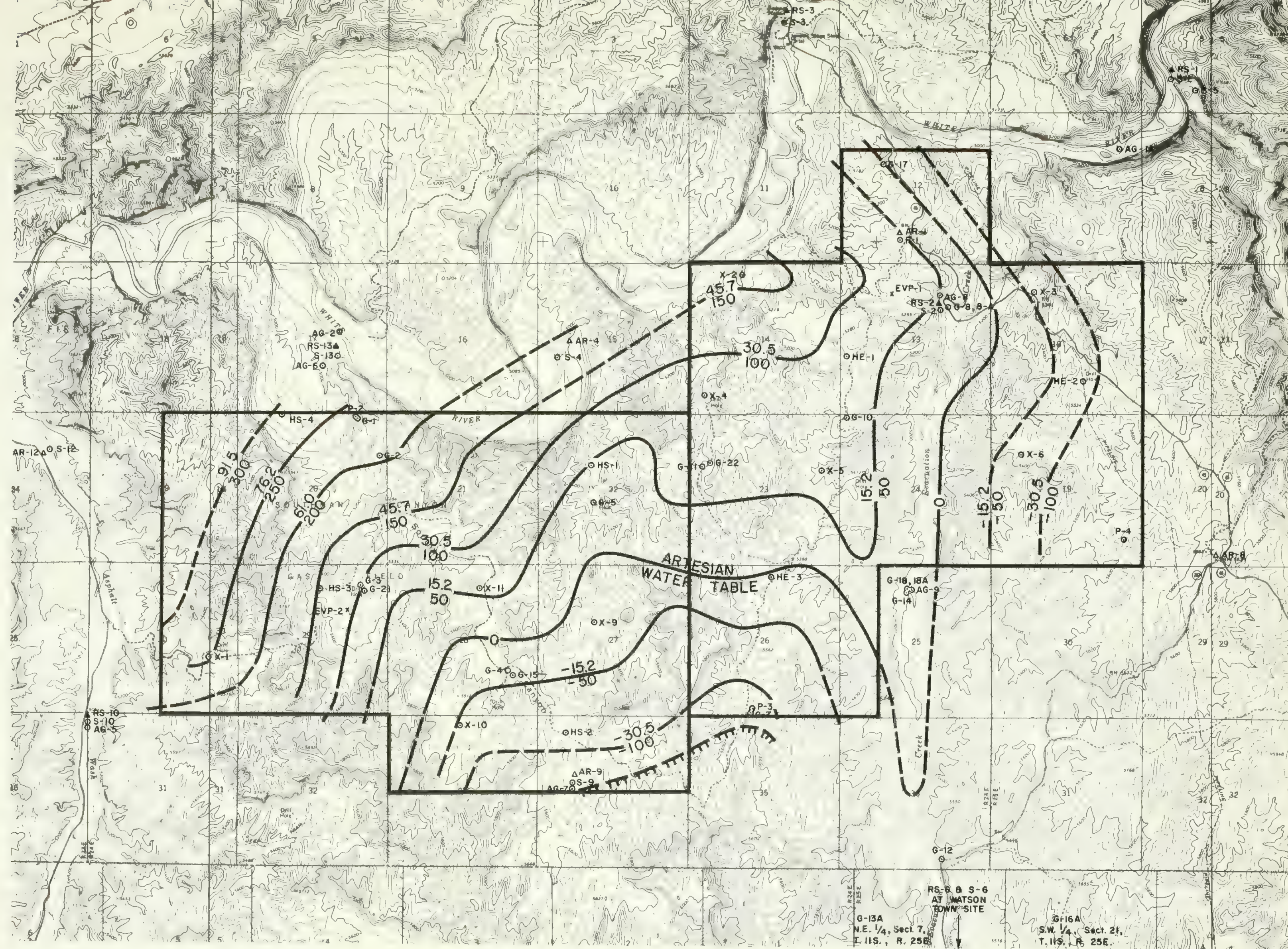
CONTOURS ON THE GROUND WATER SURFACE ABOVE OR BELOW THE TOP OF THE BIRDS NEST AQUIFER. DASHED WHERE INFERRED.

- S SURFACE WATER MONITORING STATION
- P PILOT TEST HOLE (WATER)
- G GROUND WATER MONITORING STATION
- HE EXISTING GEOLOGIC CORE HOLE, EVACUATION
- HS EXISTING GEOLOGIC CORE HOLE, SOUTHAM
- X EXPLORATION GEOLOGIC CORE HOLE
- AG ALLUVIAL WELL (WATER)
- △ AR PRECIPITATION, AUTO (WATER)
- ▲ RS PRECIPITATION, STORAGE (WATER)
- x EVP EVAPORATION PAN (WATER)



1 0 1

SCALE IN MILES

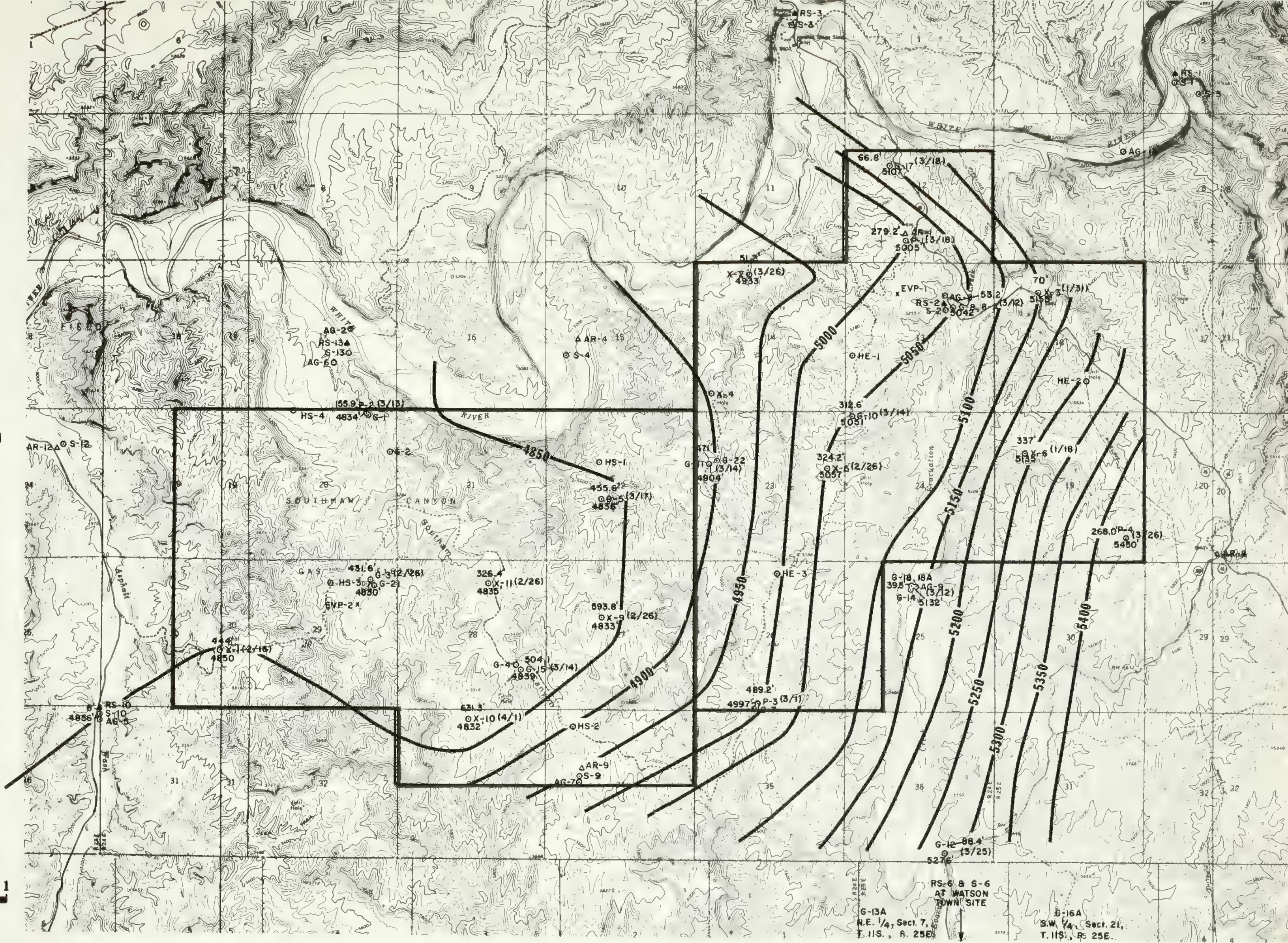
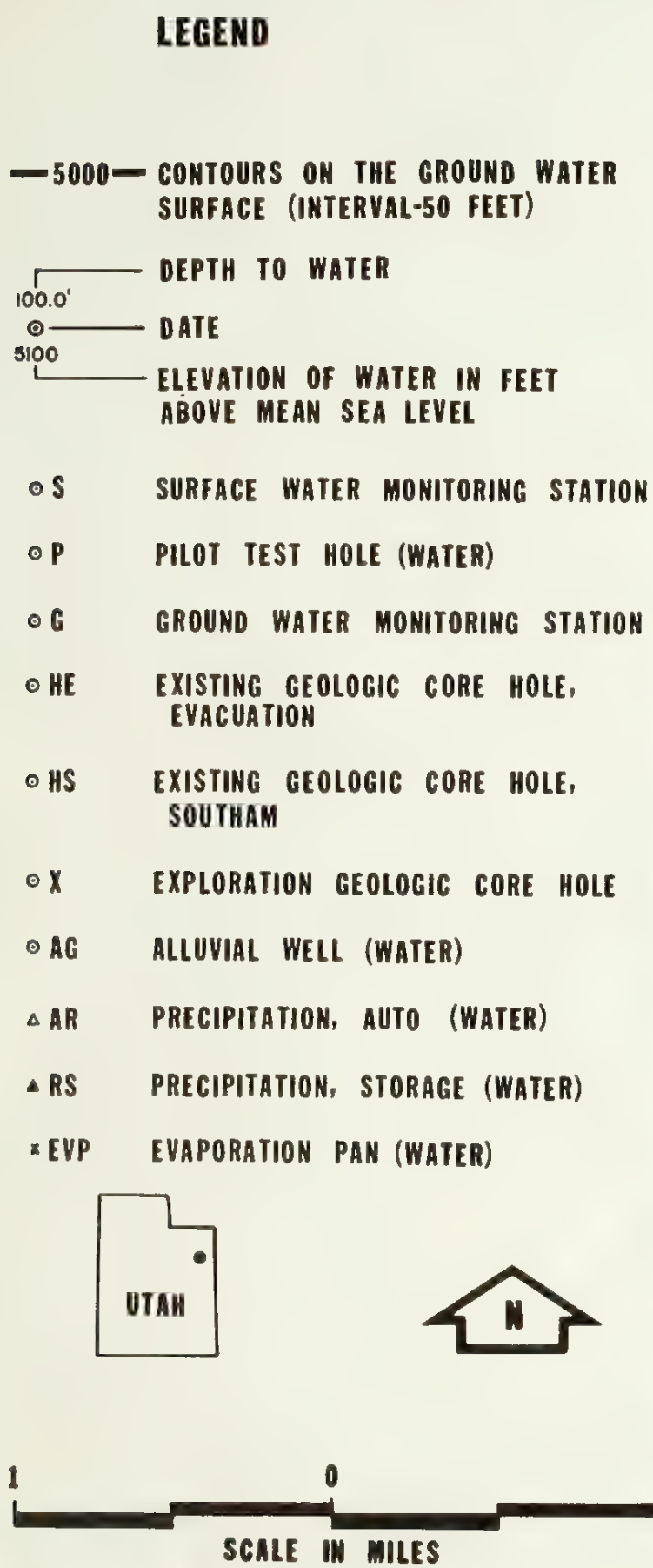


WHITE RIVER SHALE PROJECT
BIRDS NEST AQUIFER
WATER TABLE AND ARTESIAN CONDITIONS
(ADJUSTED TO DEC. 1974 WATER LEVELS)
EASTERN UINTA BASIN, UTAH

FIGURE II-74

II-125





CONTOURS ON THE GROUND WATER SURFACE OF THE BIRDS NEST AQUIFER, MARCH, 1975

FIGURE II-75

During the summer of 1975 three aquifer tests were conducted in wells penetrating the bird's nest aquifer. The results of the tests are summarized on Table II-13. Each test site was designed for a pumping well and two observation wells spaced about 15 m (50 ft) and 30 m (100 ft) from the pumping well. Test site P-3, however, produced so little water that records were obtained from the pumped well only. The tests did not reveal anything unexpected, such as interformational leakage or recharge from the White River. A more comprehensive discussion of the tests and interpretations are in the FYEBR. Aquifer tests were not conducted in either the alluvium or the Douglas Creek Member.

d. Ground Water Recharge

The bird's nest aquifer is known to occur within 15.2 m to 38.1 m (50 ft to 125 ft) below the top of the Green River Formation and could follow the outcrop pattern for a great distance around the edges of the Uinta Basin if the aquifer is present everywhere in the formation. It is not known whether the aquifer extends beyond 8 km to 9.5 km (5 mi to 6 mi) from the tracts.

Near the junction of U.S. 40 and Utah State Road 45 the Parachute Creek Member dips steeply along its northern edge at the rate of 189 m/km to 284 m/km (1000 ft/mi to 1500 ft/mi). In these areas the member is upturned against the ground surface slope (Barlow & Haun, Inc. 1962). The results of the field investigations indicate that if the bird's nest aquifer is present in this area, it is covered by the Duchesne River Formation. Under these conditions, exposures of the aquifer would be excellent for recharge from direct precipitation, snowmelt, and runoff.

Conditions are not suited for significant recharge around the south of the tracts. The aquifer dip is not known to exceed 57 m/km (300-ft/mi), and as a result the aquifer is usually exposed above canyon floors on nearly vertical walls.

Where the aquifer is in contact with alluvium--in the bottom of Evacuation and Bitter creeks, Asphalt Wash, Hells Hole Canyon, and the White River--the recharge potential is increased. This is best illustrated in portions of Sections 34 and 35, T10S, R24E, and at least as far south as G-19 (Section 14, T11S, R24E), where the aquifer is essentially dry. Beginning in Section 6, T10S, R24E, the aquifer is in contact with the alluvium of Evacuation Creek, and it contains water at all locations from that point northward across the tracts.

TABLE II-13

AQUIFER PUMP TEST RESULTS

Observation Well Distance From Pumping Well(r) in ft.	Observation Well Designation	Method of Analysis	Period of Test	Calculated Aquifer Coefficients	
				Transmissibility (T) gallons/day/ft.	Storage
P-1 Test Q = 45 gpm Duration of Pumping = 1800 min.	---	P-1 Pump	Time - Drawdown (Jacob)	2475 (early slope)	---
				1458 (late slope)	---
			Pumping		
	52.0	P-1 Pilot	Time - Drawdown (Jacob)	914 (early slope)	3.35×10^{-4}
				1627 (late slope)	---
			Residual Drawdown	972	---
			Calculated Recovery	1024	3.40×10^{-4}
	101.5	P-1 Core	Drawdown vs. Radius	1800	
			Time - Drawdown - (Jacob)	1789	3.80×10^{-4}
			Residual Drawdown	1584	---
P-2 Upper Test Q = 10 gpm Duration of Pumping = 1676 min.	---	P-2 Upper Pump	Time - Drawdown (Jacob)	120 (early slope)	---
				27 (middle slope)	---
				15 (late slope)	---
	48.0	P-2 Upper Pilot	Time - Drawdown (Jacob)	120 (early slope)	1.6×10^{-5}
				27 (middle slope)	---
				15 (late slope)	---
			Residual Drawdown	25 (middle slope)	---
	98.0	P-2 Upper Core	Time- Drawdown (Jacob)	123 (early slope)	1.07×10^{-5}
				36 (middle slope)	---
			Residual Drawdown	17 (late slope)	---
			Recovery	28 (middle slope)	---

TABLE II-13 (Cont.)

Observation Well Distance From Pumping Well(r) in ft.	Observation Well Designation	Method of Analysis	Period of Test	Calculated Aquifer Coefficients		
				Transmissibility (T) gallons/day/ft.	Storage	
	P-2 Lower Pump		Pumping Recovery	---	---	
48.6	P-2 Lower Pilot	Time - Drawdown (Jacob)	Pumping	62,586 (early slope)	6.77×10^{-6}	
				111,692 (late slope)	---	
		Calculated Recovery	Recovery	69,173	1.14×10^{-5}	
		Residual Drawdown		69,173	---	
94.9	P-2 Lower Core	Time - Drawdown (Jacob)	Pumping	63,130 (early slope)	8.29×10^{-5}	
				103,714 (late slope)	---	
		Calculated Recovery	Recovery	68,514	3.13×10^{-5}	
		Residual Drawdown		66,304	---	
	P-2 Lower Core & Pilot	Distance - Drawdown vs. Radius	Pumping Radius	69,339	1.68×10^{-4}	
		Time - Drawdown (Theis)		74,500		
P-3 Test	P-3 Pump		Pumping	58	0.105	
		Time - Drawdown (Jacob)		61 (early slope)	0.085	
			26 (late slope)	---		
Duration of Pumping = 8765 min.		Residual Drawdown	Recovery	6.7	---	

No water wells other than those drilled for this investigation are known to produce water exclusively from the bird's nest aquifer. Two flowing wells originally drilled for oil and gas exploration in Asphalt Wash were intended to be sealed through the aquifer, but leakage may be occurring from the bird's nest anyway. It is thought that production of water from the bird's nest in the vicinity of the tracts is minimal; this, the known discharge areas, and minimal water-level fluctuations indicate that the aquifer is under steady-state conditions, i.e., discharge equals recharge. Intraformational or interformational leakage is not expected to be a significant source of recharge to the bird's nest aquifer because the major aquifer zones are too well shielded from one another by extensive layers of shaley material.

e. Ground Water Movement and Fluctuation

Data concerning water levels in the bird's nest aquifer are not available from wells of record in the vicinity of the tracts except from wells drilled for the baseline data collection program. The other wells of record--deep oil-test and gas-test holes--are not reliable indicators of water levels because the levels are a composite of many aquifers. Because data for the water level north of the tract boundaries are not available, it can only be speculated that recharge water migrates from the northern outcrop area and around the rim of the basin to the east to be discharged at points along Evacuation Creek and the White River.

The water-level contours probably conform to the shape of the west-dipping structural contours throughout most of the reach between the U.S. 40 - Utah 45 junction and the tracts. As the contours approach the area of the confluence of Evacuation Creek and the White River, which acts as a pressure sink, the contours probably bend sharply downstream and after crossing the stream, probably bend sharply upstream, enter the tracts, and generally reconfom to the regional structural trends. This theory is supported by the pattern of the tract water level contours (Figure II-75). It is also noted that water levels slope toward the west as much as 83.3 m/km (175 ft/mi) across Tract U-b but are at about the same elevation over most of Tract U-a. This is a further indication that the transmissivity at the P-2 site is much higher than that of the P-1 site.

Water levels were continuously recorded at the four P sites from December 1974 through December 1976, as seen on figures II-75 through II-79. The water levels of the other wells drilled as part of the baseline program were measured at least monthly, as seen on Figure II-80.

LEGEND

**—5000— CONTOURS ON THE GROUND WATER
SURFACE (INTERVAL-50 FEET)**

DEPTH TO WATER

① _____ DATE

ELEVATION OF WATER IN FEET
ABOVE MEAN SEA LEVEL

◉ S SURFACE WATER MONITORING STATION

PILOT TEST HOLE (WATER)

⊙ G GROUND WATER MONITORING STATION

• HE EXISTING GEOLOGIC CORE HOLE, EVACUATION

◉ HS EXISTING GEOLOGIC CORE HOLE,
 SOUTHAM

⊙ X EXPLORATION GEOLOGIC CORE HOLE

• AG ALLUVIAL WELL (WATER)

△ AR PRECIPITATION, AUTO (WATER)

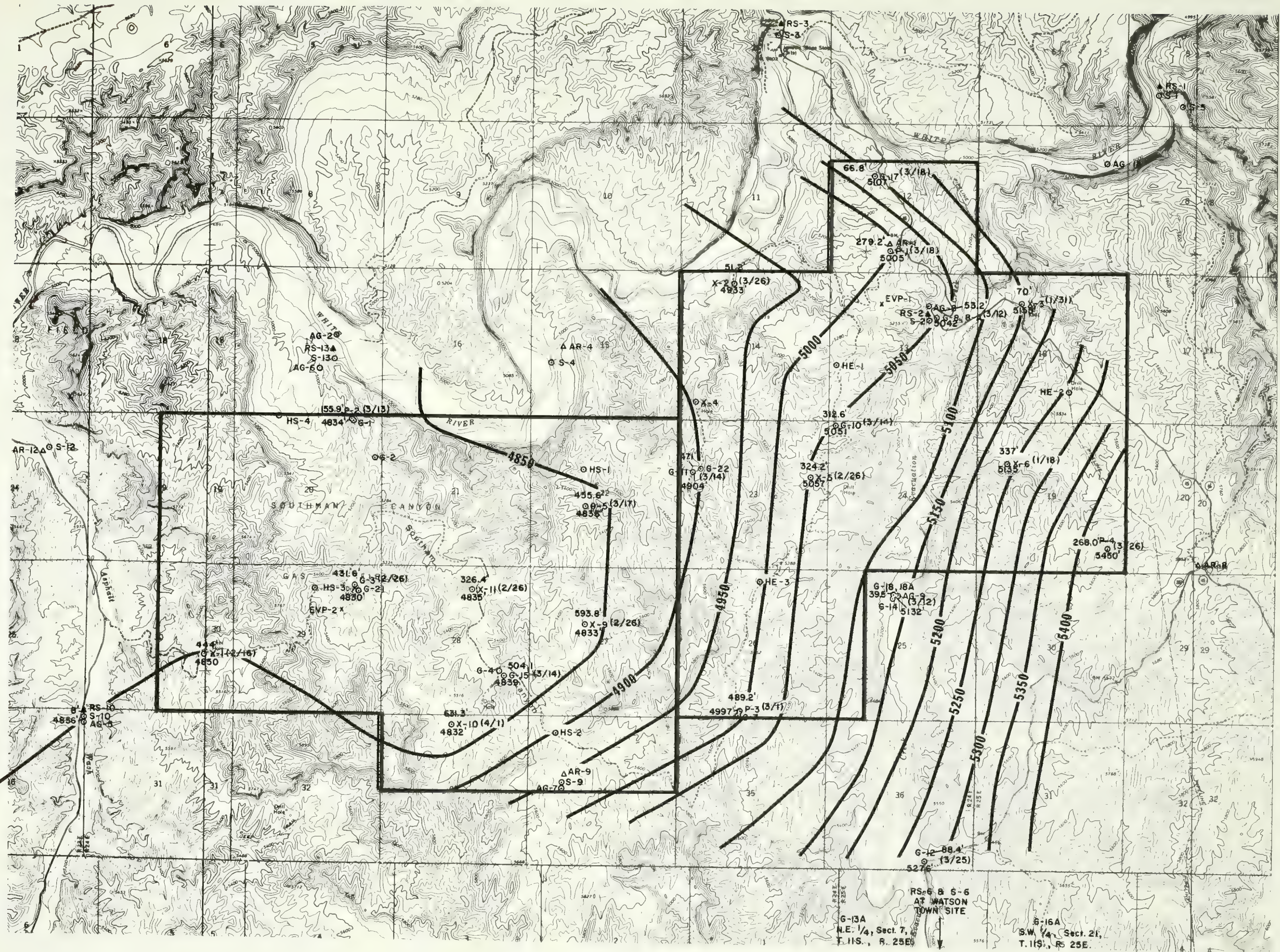
▲ RS PRECIPITATION, STORAGE (WATER)

* EVP EVAPORATION PAN (WATER)



N

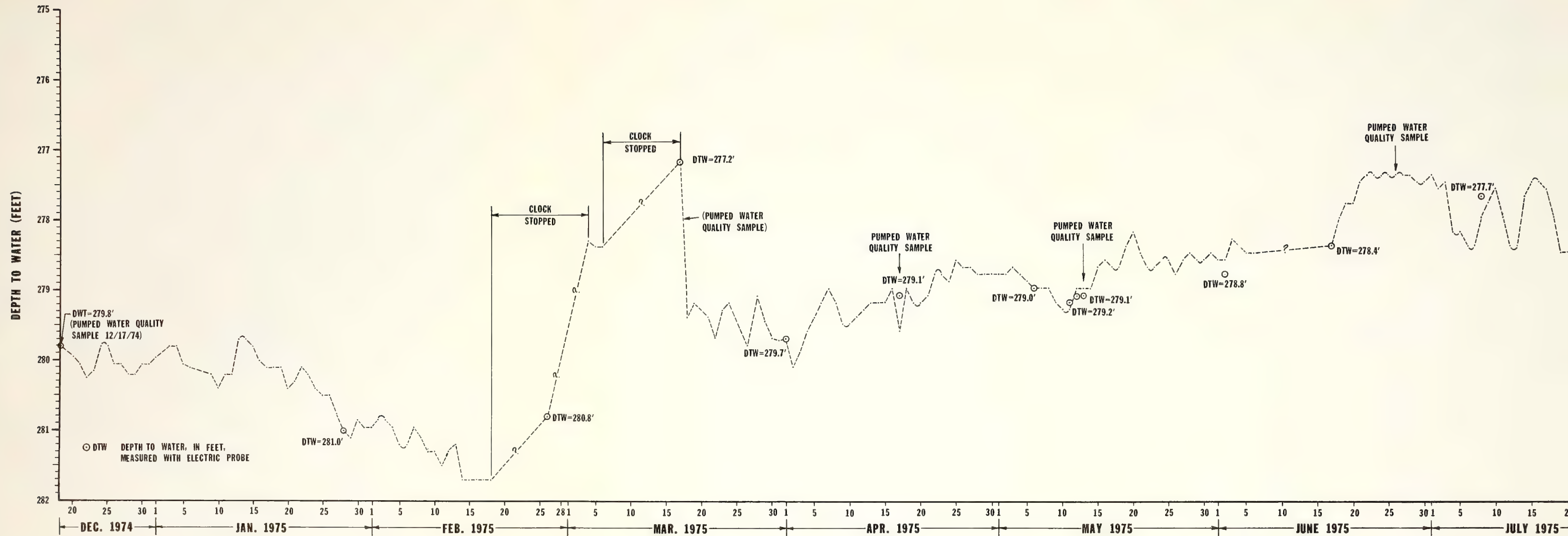
SCALE IN MILES



CONTOURS ON THE GROUND WATER SURFACE OF THE BIRDS NEST AQUIFER, MARCH, 1975

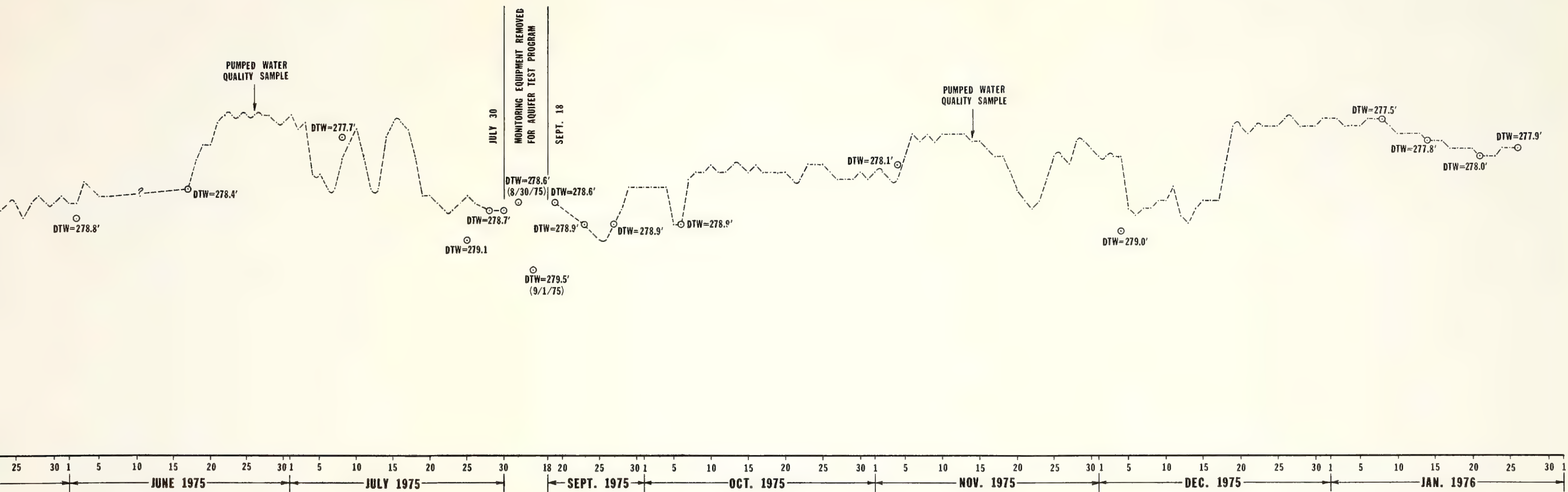
FIGURE 11-75

II-130



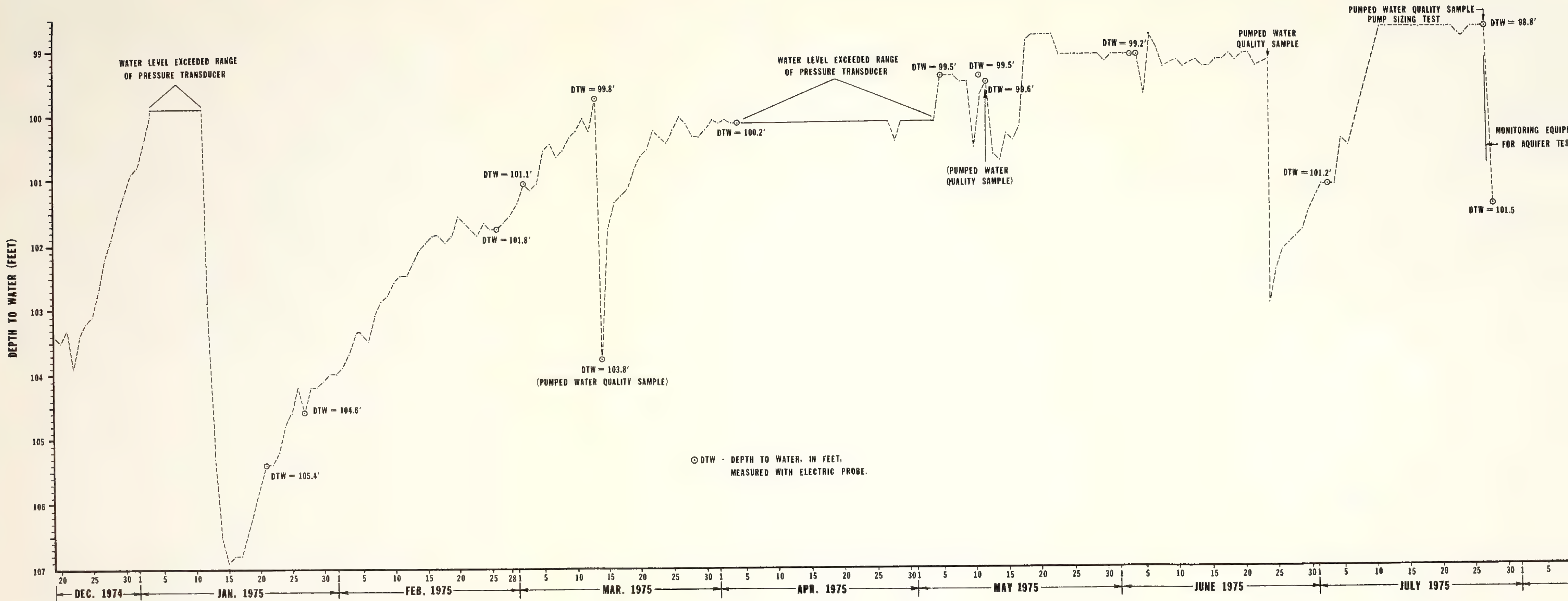
CONTINUOUS MONITORING WELL P-1
(SURFACE ELEVATION 5284.0')





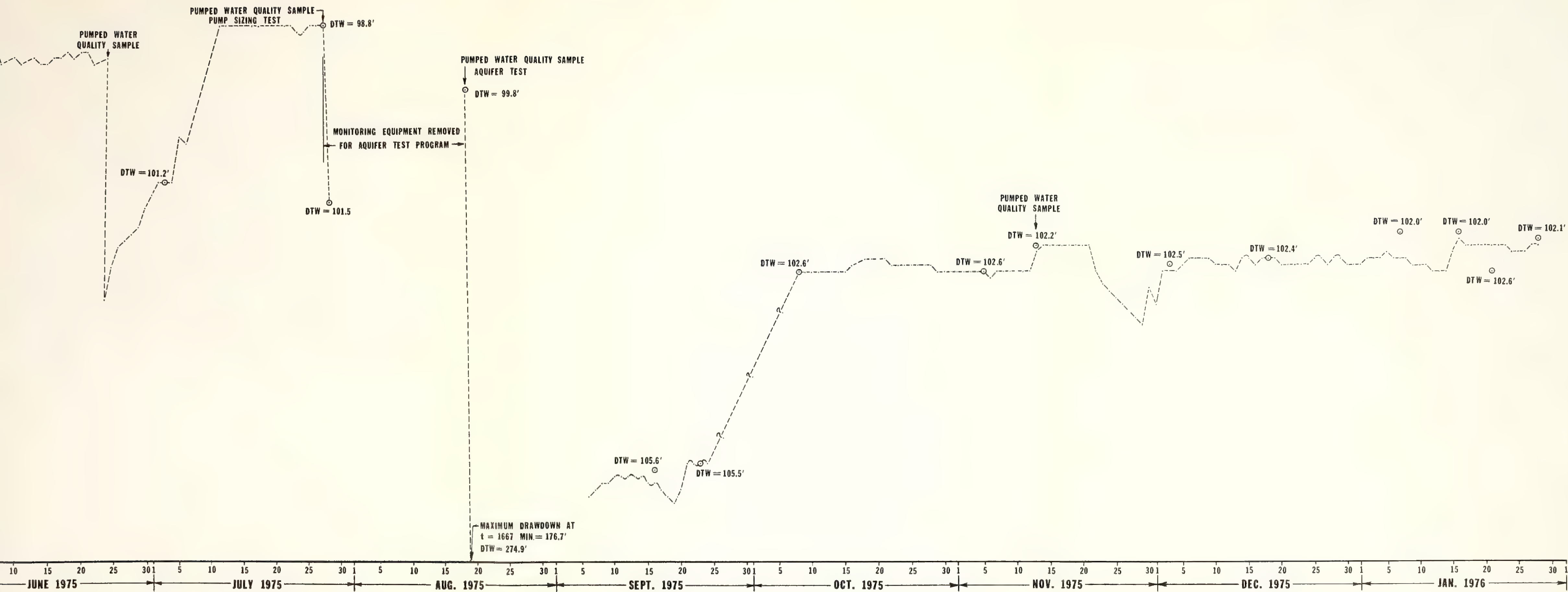
CONTINUOUS MONITORING WELL P-1
(SURFACE ELEVATION 5284.0')

FIGURE II-76



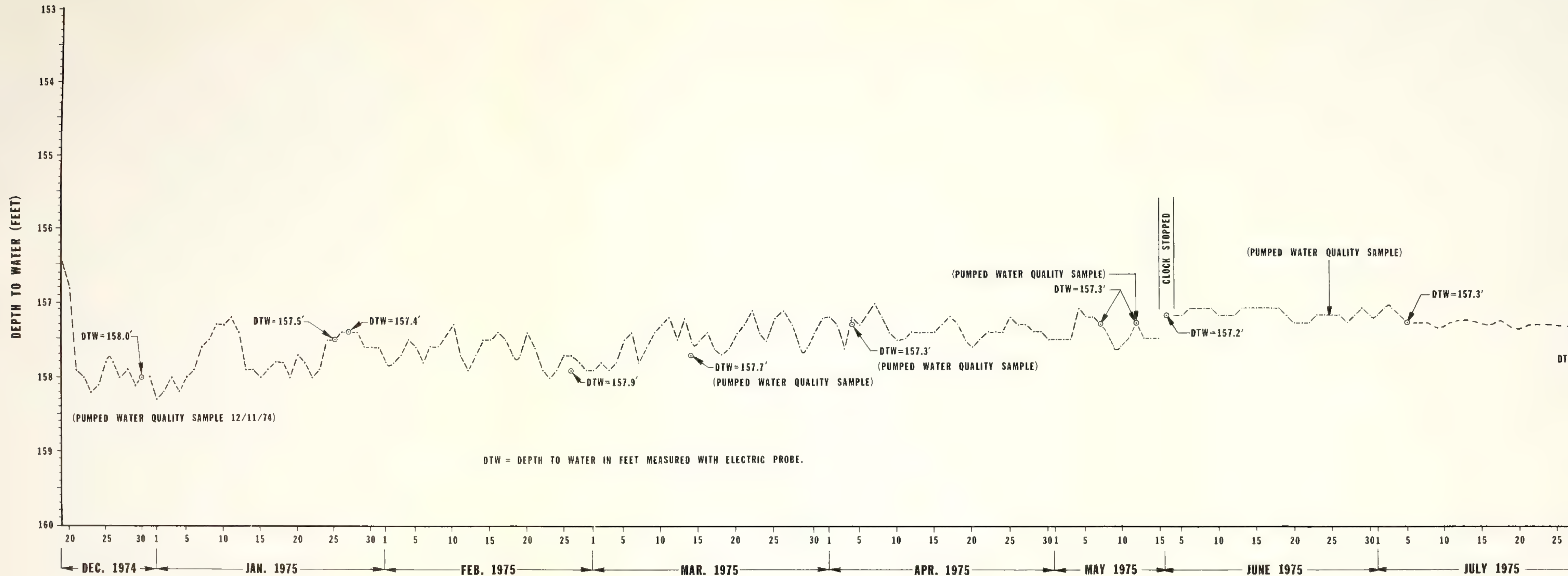
CONTINUOUS MONITORING WELL P-2 UPPER
(SURFACE ELEVATION 4991.0')





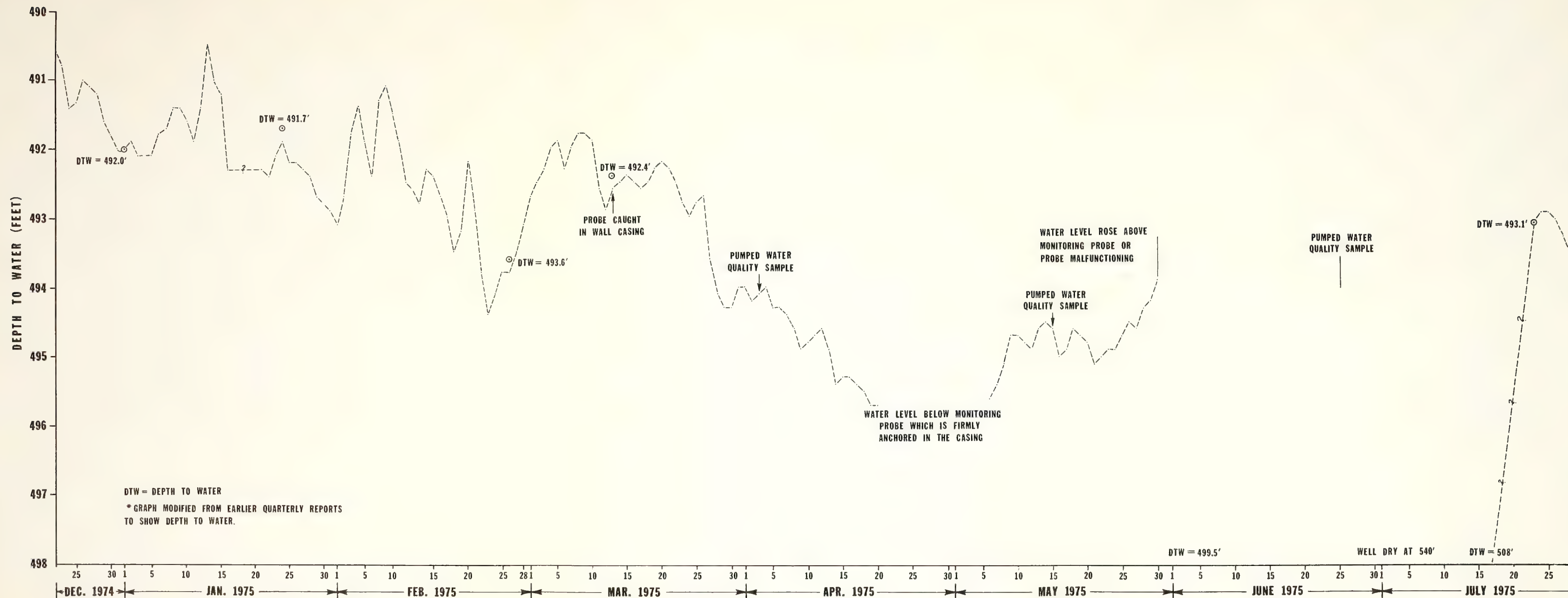
CONTINUOUS MONITORING WELL P-2 UPPER
(SURFACE ELEVATION 4991.0')

FIGURE II-77



CONTINUOUS MONITORING WELL
P-2 LOWER
(SURFACE ELEVATION = 4991.0 FT.)

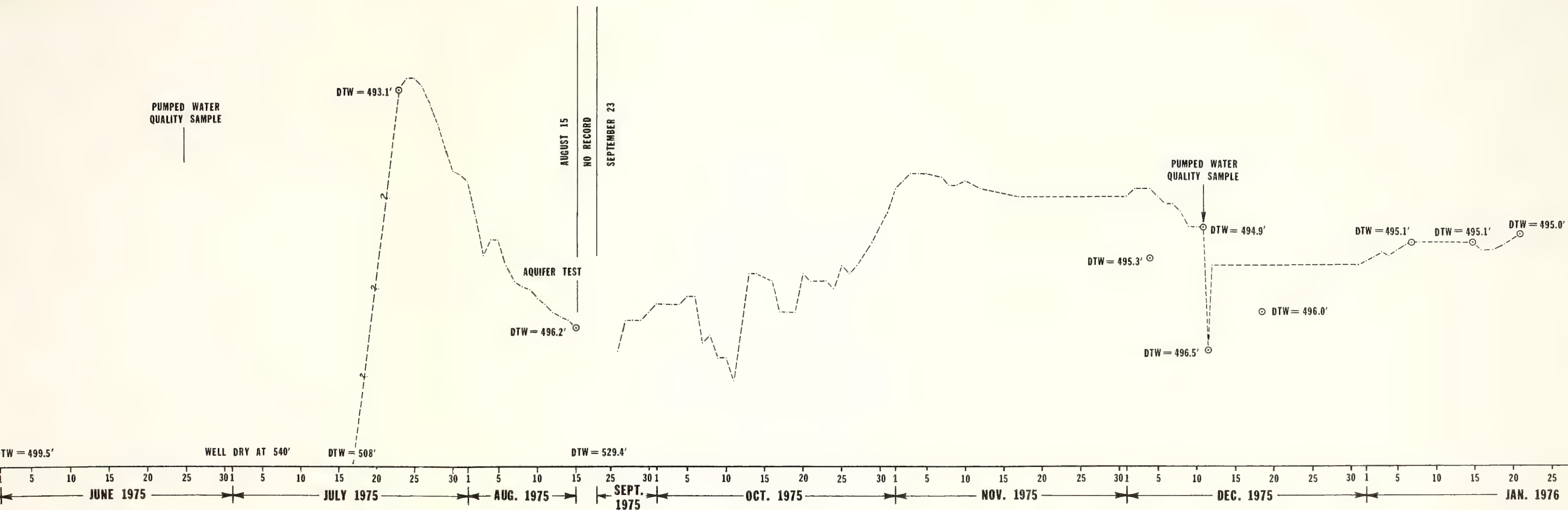




CONTINUOUS MONITORING WELL G-7* (P-3)

(SURFACE ELEVATION = 5486')

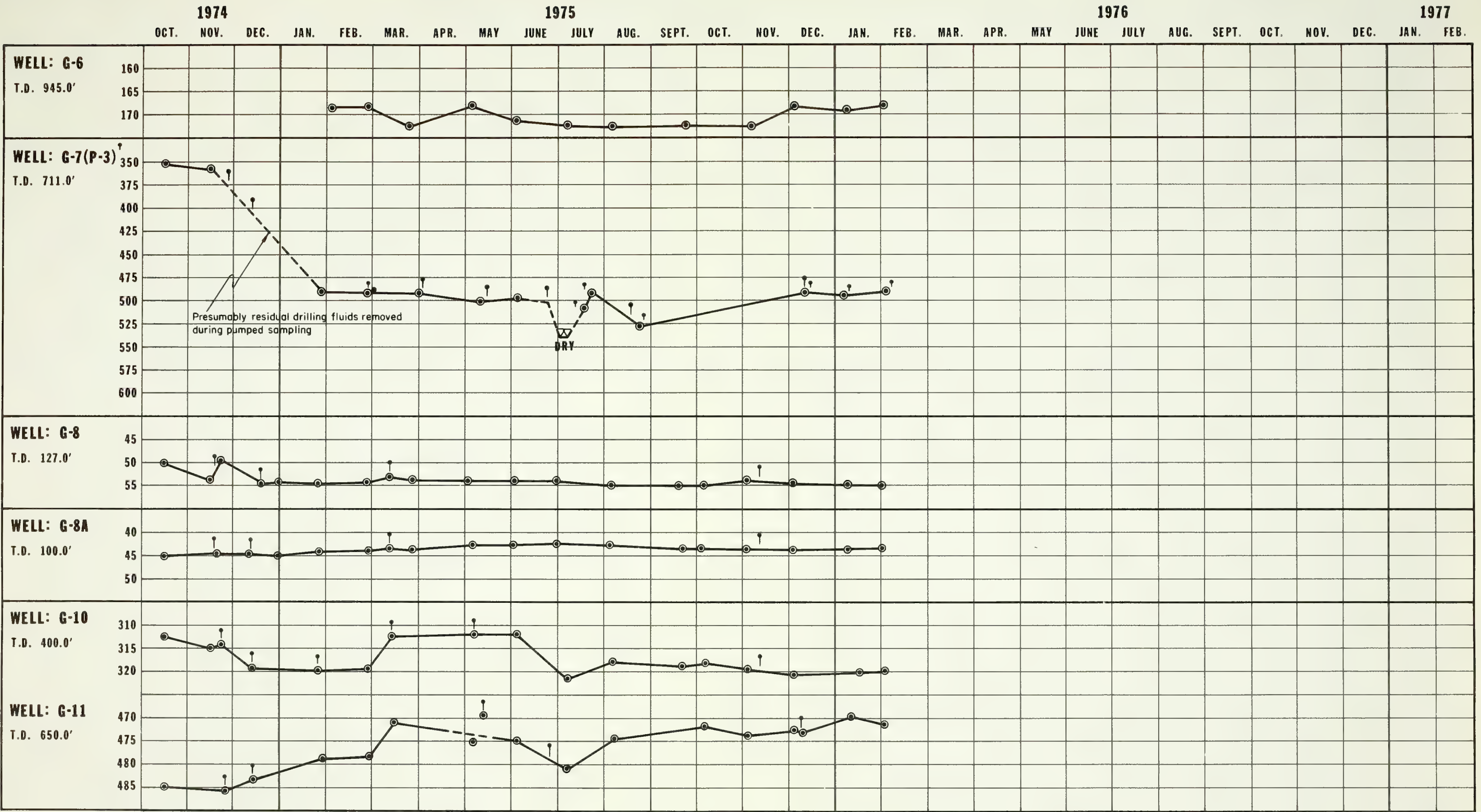




CONTINUOUS MONITORING WELL G-7* (P-3)

(SURFACE ELEVATION = 5486')

FIGURE II-79

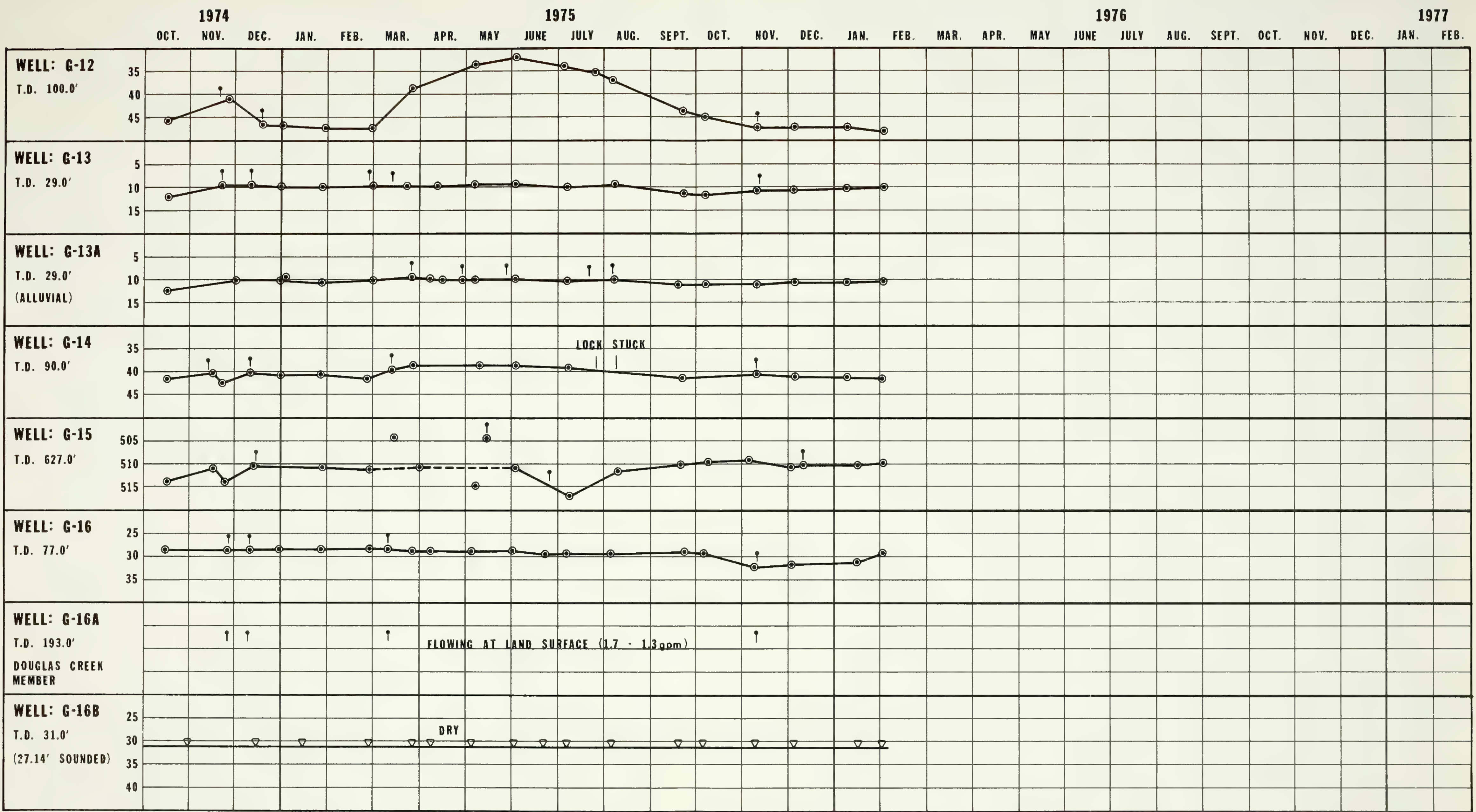


▽ - MEASUREMENTS IN DRY HOLE † - PUMPED OR THIEVED WATER QUALITY SAMPLE ● - WATER SURFACE MEASUREMENTS

MONTHLY MEASURED STATIC WATER LEVELS IN WELLS OCT. 1974 - FEB. 1976
WHITE RIVER SHALE PROJECT TRACTS U_a & U_b

FIGURE II-80 (CON'T)



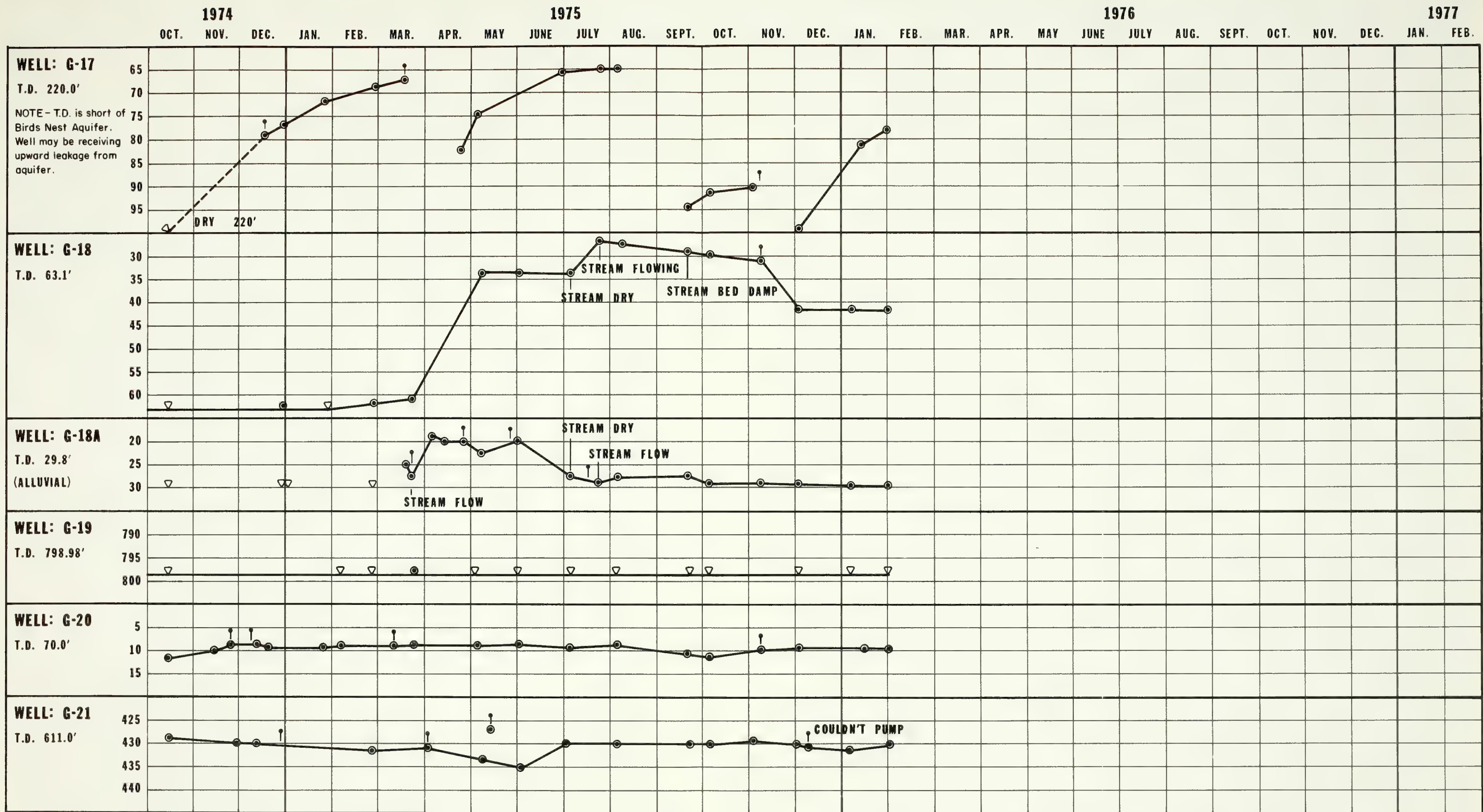


▽ - MEASUREMENTS IN DRY HOLE † - PUMPED OR THIEVED WATER QUALITY SAMPLE ● - WATER SURFACE MEASUREMENTS

MONTHLY MEASURED STATIC WATER LEVELS IN WELLS OCT. 1974 - FEB. 1976
WHITE RIVER SHALE PROJECT TRACTS U_a & U_b

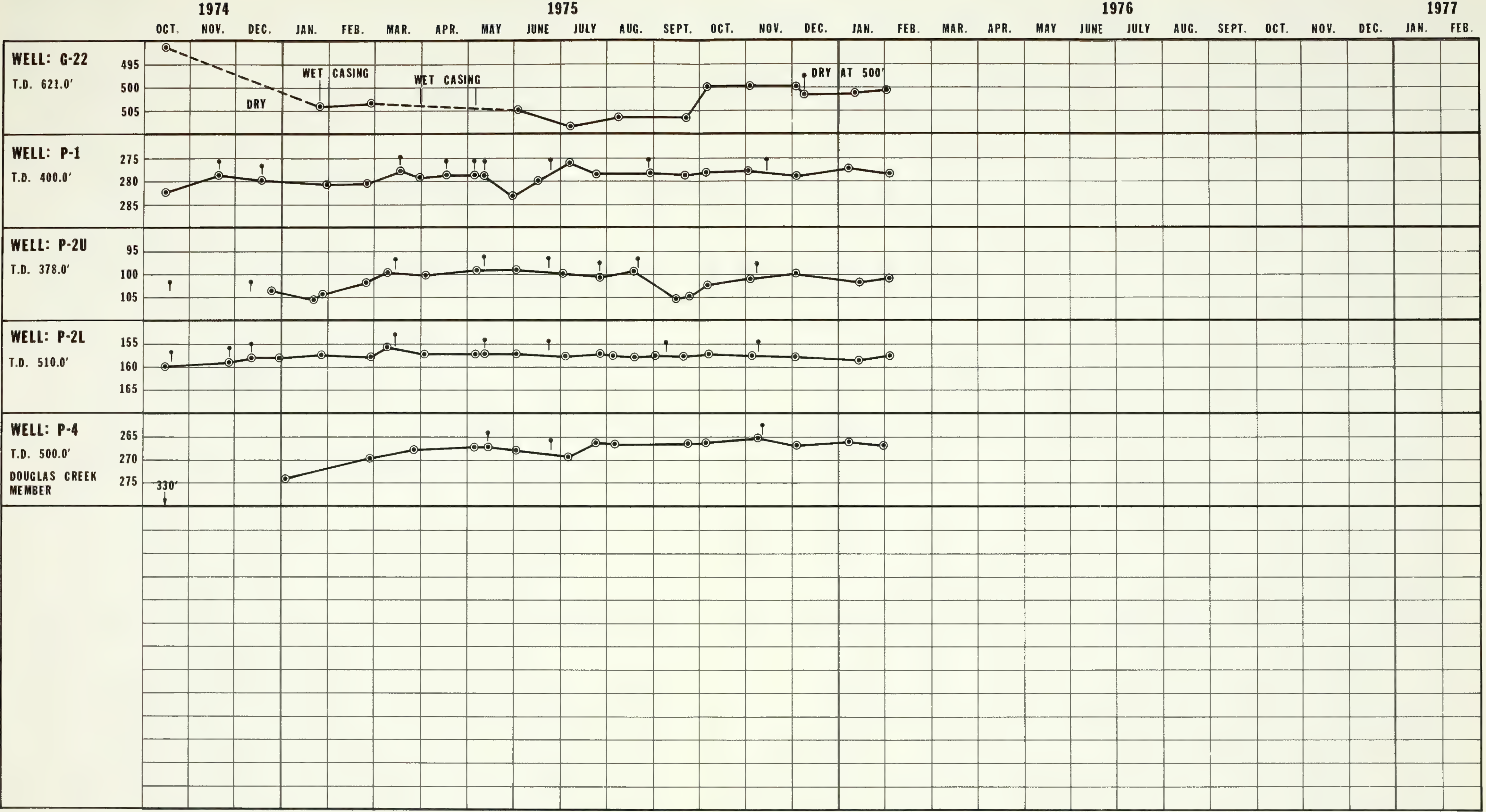
FIGURE II-80 (CON'T)





MONTHLY MEASURED STATIC WATER LEVELS IN WELLS OCT. 1974 - FEB. 1976
 WHITE RIVER SHALE PROJECT TRACTS Ua & Ub

FIGURE II-80 (CON'T)



▽ - MEASUREMENTS IN DRY HOLE ↑ - PUMPED OR THIEVED WATER QUALITY SAMPLE ● - WATER SURFACE MEASUREMENTS

MONTHLY MEASURED STATIC WATER LEVELS IN WELLS OCT. 1974 - FEB. 1976
WHITE RIVER SHALE PROJECT TRACTS Ua & Ub

FIGURE II-80 (CON'T)



Some of the wells, depending on their geographic location in the body of the aquifer, show that aquifer recharge began in late February 1975 or early March 1975 and declined in early June (e.g., G-10, G-11, G-12, G-14, shown on Figure II-75). These wells are in an area of the bird's nest aquifer that receives recharge from Evacuation Creek or where it is exposed at the ground surface and is subject to direct recharge from precipitation (e.g., G-12). Water levels in wells away from the outcropping edges of the aquifer show no such response to recharge, indicating that the main body of the reservoir is full to capacity.

It has been established that the water contained in the bird's nest aquifer is under artesian pressures at the P-1, P-2 upper, and P-2 lower continuous water-level recording sites. As demonstrated by Ferris and others (1962), artesian water levels should fluctuate in response to changes in barometric pressures, and the ratio of water level change in feet to the barometric change in feet of water can be used to determine the barometric efficiency of an aquifer. The barometric efficiency of an artesian aquifer is an index to its elasticity.

The period beginning in early April 1976 and extending through early May 1976 was selected for analysis of the bird's nest aquifer's barometric efficiency. The water-level and water-pressure data are summarized as hourly averages on figures II-81 through II-84. Since an increase in barometric pressure will create a water-level decline, the barometric pressure is reversed for direct comparison to changes in depth to water. Figure II-81 shows barometric-pressure-induced water-level fluctuations in the bird's nest aquifer at the P-2 lower site. The barometric efficiency as determined from the graphs during the large pressure decline during mid-month ($\Delta p = 15$ cm [0.5 ft]) caused water levels to rise about 13 cm (0.425 ft), which translates to a barometric efficiency of about 85%.

The curves shown on Figure II-82 show the pressure and water-level traces at the P-1 location and indicate an efficiency of about 65%. This well location is nearer the outcrop of the aquifer than is the P-2 lower site, and its efficiency may be somewhat affected by its closeness to the outcrop.

At the P-2 upper site (Figure II-83), the flat spots on the water-level curve suggest that the recorder float tended to hang up near the 31-m (102-ft) level. Accordingly, no calculations of efficiency were attempted; however, the general correlation is obvious.

Figure II-84 contains the pressure and water-level traces for the P-3 site. The data suggest an efficiency of more

than 100%, even though the water in this well is under water-table conditions. This well periodically emits hydrogen sulphide gas, and its water-level fluctuation is undoubtedly affected by the gas generation.

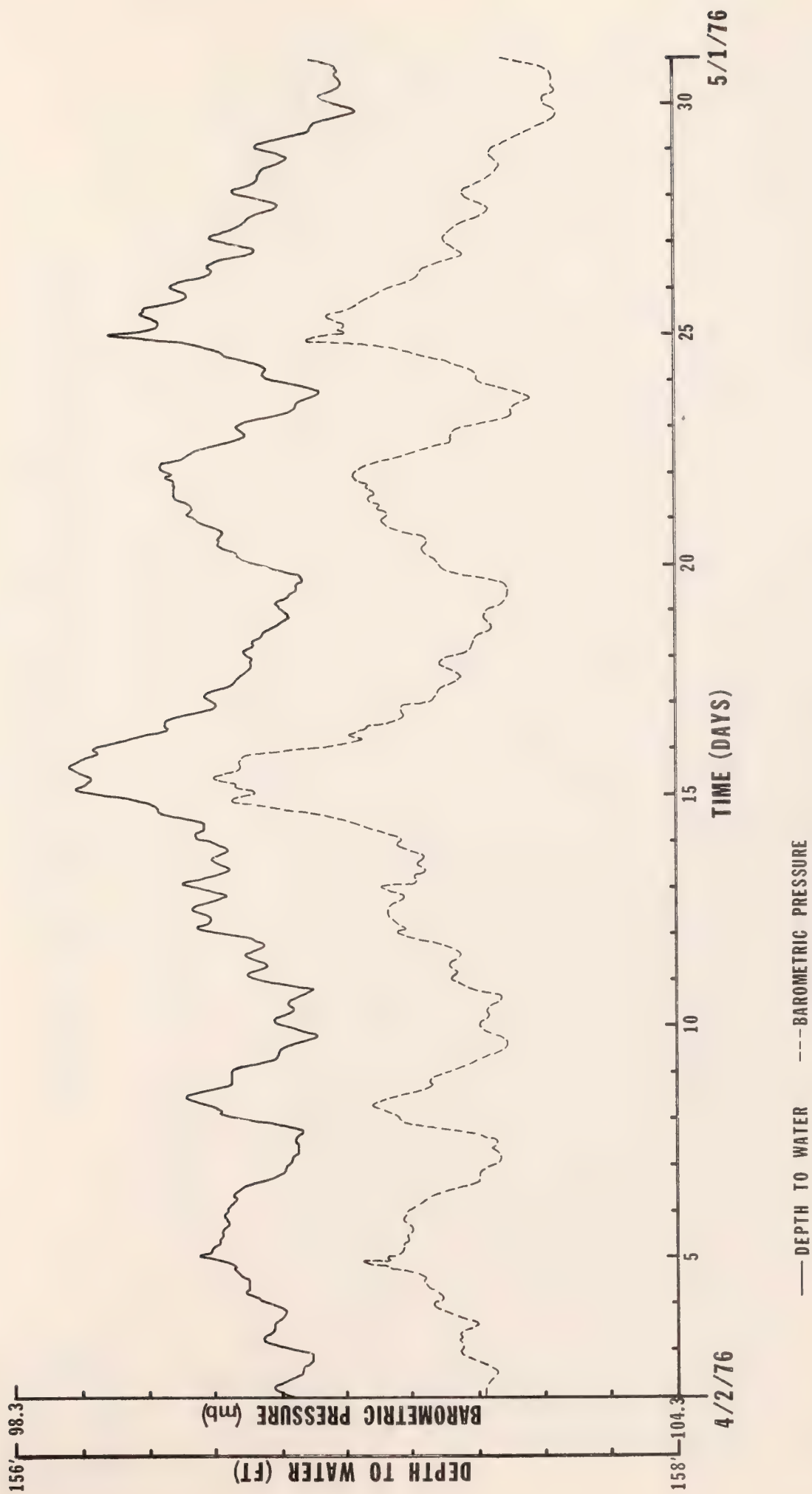
As a part of the Conditions of Approval to the Ground Water Partial Exploration Program in November 26, 1976 and January 26, 1976, the AOSSO directed that 5.1-cm (2-in.) alluvial wells be installed at designated locations along the White River, Evacuation Creek, Southam Canyon, and Asphalt Wash. These are designated "AG" on Figure II-75. The Conditions of Approval specified that if more than 4.6 m (15 ft) of saturated material was encountered at any of the designated locations, a well point would be installed to bedrock, and another well point would be set to a depth of 0.5 m to 1.5 m (2 ft to 5 ft) below the water surface (designated as "upper"). Eleven wells were installed January 1976 and measured monthly thereafter to determine water-level fluctuations (figures II-81 through II-84).

Generally, very little water-level fluctuation was observed in any of the alluvial wells. Well AG-6, in lower Southam Canyon, has shown a gradual but steady decline in water level over the period of record. Elsewhere in the alluvial deposits of the drainage upstream from AG-6 (G-1A, G-2A, G-3A, and AG-7) no alluvial water was encountered. AG-6 is downstream of the P-2 site, where up to about 44.1 l/s (700 gpm) were discharged into the alluvial channel for about 30 days during drilling in September-October 1974, and a 6-day aquifer test during August 1975 discharged 34.7 l/s (550 gpm) onto the alluvial floor. It is felt that the saturation at the AG-6 site is a result of prior drilling and testing discharges and not the result of basin-wide accumulation and underflow.

f. Ground Water Discharge

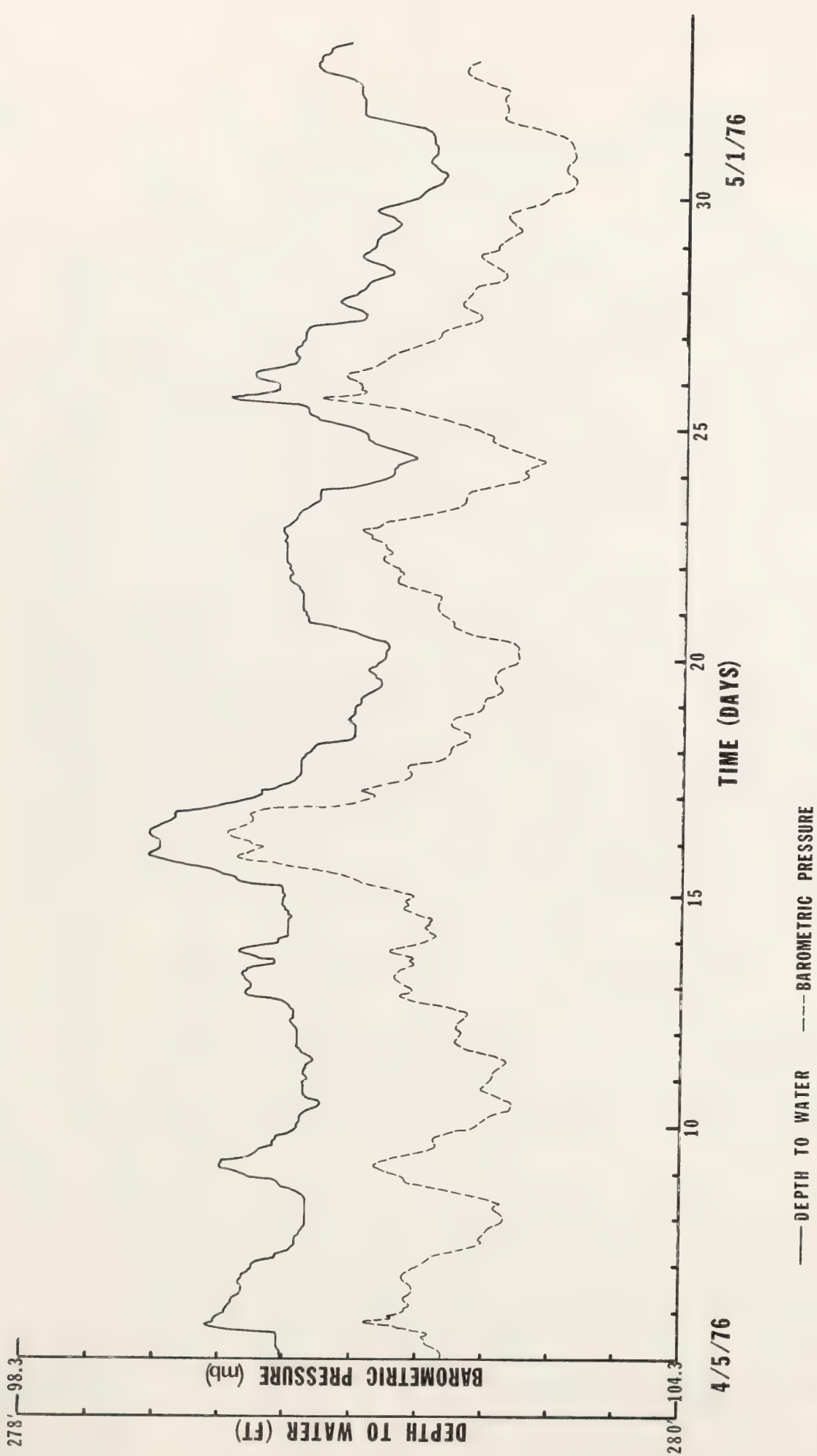
Discharge from the bird's nest aquifer in the form of seeps and springs is common along the portion of the aquifer exposed in the walls of Hells Hole and Evacuation Creek canyons. Based upon earlier discussions of water-level fluctuations and recharge, the aquifer is apparently under equilibrium conditions and recharge equals discharge.

The main body of the aquifer is full to capacity, as indicated by the springs and seeps on the west side of Evacuation Creek beginning about 1.6 km (1 mi) south of the southern boundary of Tract U-b and continuing intermittently to the confluence of the White River. Seepage is especially prevalent in the west center of Section 13, T10S, R24E, where a flow of relatively consistent quality and quantity is provided to the S-2 stream gaging site. The aquifer is also



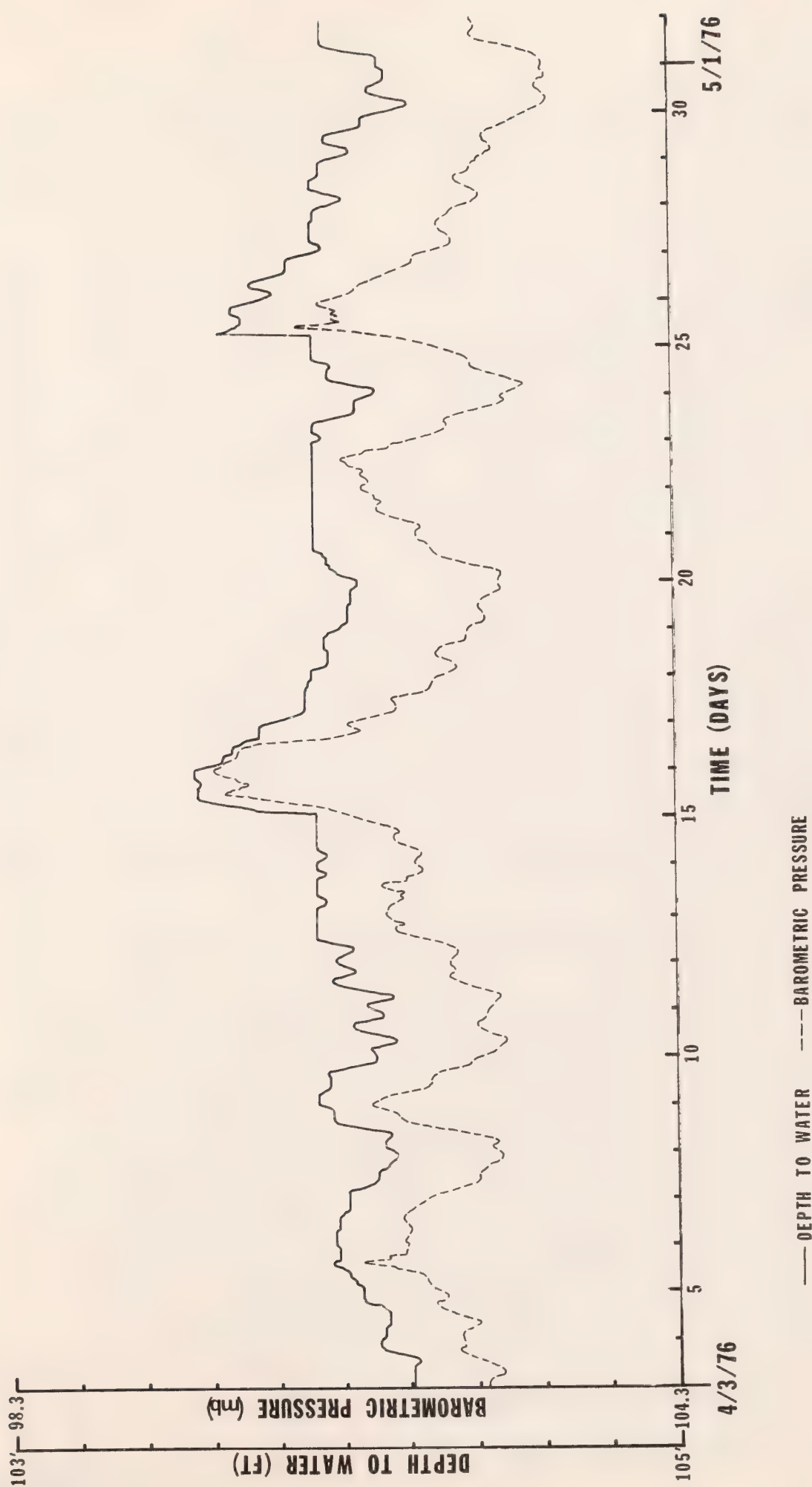
WATER LEVEL AND BAROMETRIC PRESSURE RELATIONSHIP

CONTINUOUS MONITORING WELL P-2 LOWER

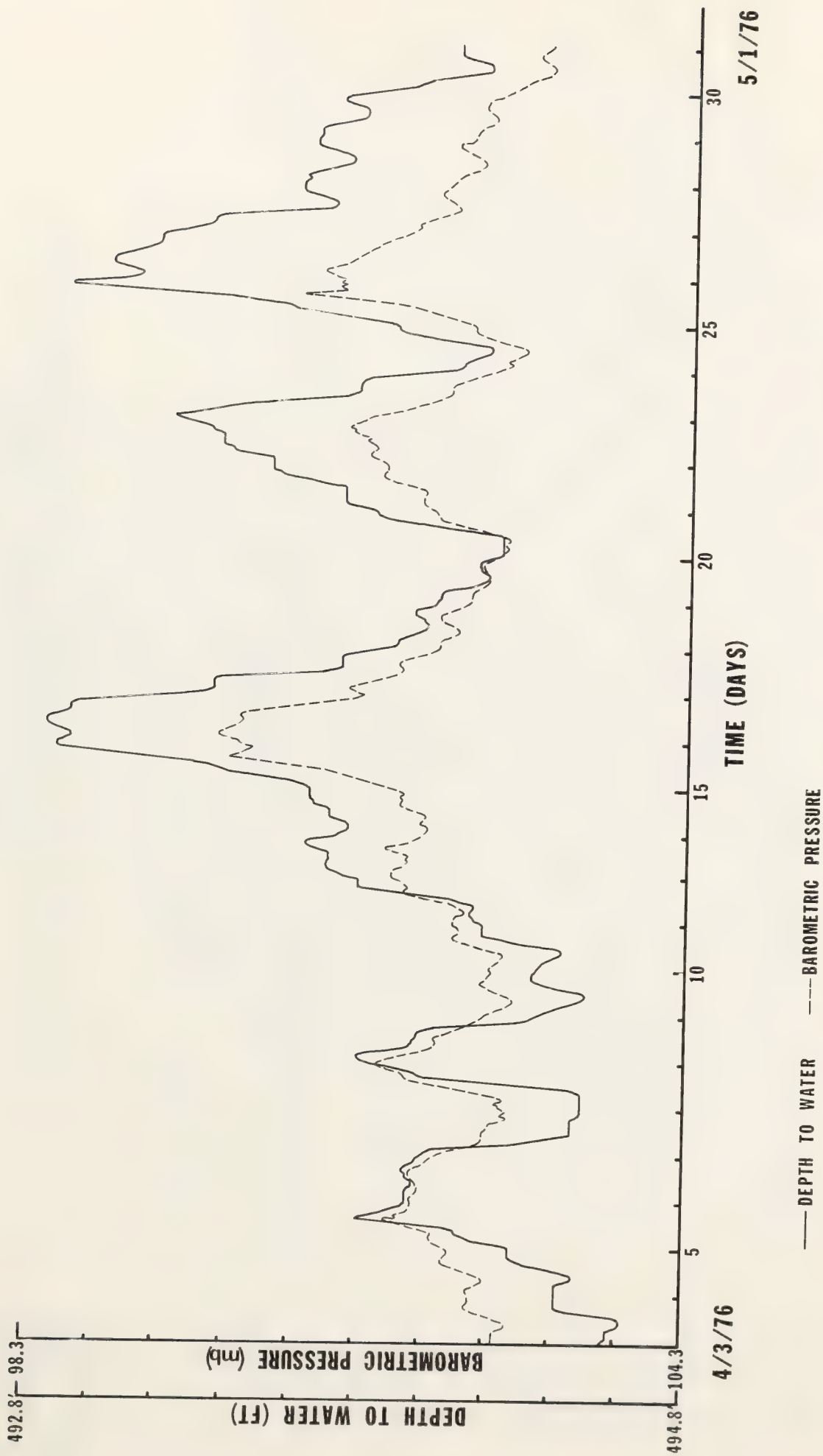


WATER LEVEL AND BAROMETRIC PRESSURE RELATIONSHIP
CONTINUOUS MONITORING WELL P-1 PUMP





WATER LEVEL AND BAROMETRIC PRESSURE RELATIONSHIP **CONTINUOUS MONITORING WELL P-2 UPPER**



WATER LEVEL AND BAROMETRIC PRESSURE RELATIONSHIP
CONTINUOUS MONITORING WELL P-3



in contact with the White River at an elevation of about 1523 m (5000 ft) in the NE¼ of the NE¼ of Section 12, T10S, R24E, and is discharging to the river at this location, as evidenced by the presence of seeps along the wall of the canyon.

Under baseflow conditions, the surface water station (S-2 near the Utah-45 bridge and Evacuation Creek) recorded flows averaging 1.42 l/s (.05 cfs) during the two last water years of record. This flow is believed to be ground water effluent from the bird's nest aquifer, which crops out in the stream-bed at that location. If this rate is assumed to be more or less constant over the past two water years, as much as $8.93 \times 10^4 \text{ m}^3$ (72.4 acre-ft) of ground water effluent may have passed the S-2 gage in the two water years. The aquifer continues to discharge into the stream for several hundred meters downstream of the surface water station, and actual ground water rates of effluent may be much larger. There is no available estimate of discharge from the aquifer outcrop in the White River on Tract U-b.

No other points of discharge from the main body of the bird's nest aquifer have been observed within the area of investigation. Bitter Creek and the Green River may be additional discharge points in T10S, R19E, but Price and Miller (1974) did not inventory any springs where the bird's nest aquifer would be expected to outcrop. Price and Miller (1974) suggested that ground water accretion to streamflow in the southern Uinta Basin area (bounded by the Duchesne, White, and Strawberry rivers) is approximately $3.7 \times 10^7 \text{ m}^3$ (30,000 acre-ft) per year. They also estimated the combined ground water production from wells in the southern Uinta Basin to be about $6.17 \times 10^5 \text{ m}^3$ (500 acre-ft) per year.

g. Ground Water Storage and Change in Storage

Ground water in storage includes the saturated portion of the aquifer and any volume of water under artesian pressure. The ground water storage estimates for the tracts are summarized on Table II-14.

As previously noted, data and observations of the bird's nest aquifer indicate that as the water level rises, the discharge into Evacuation Creek (and presumably into the White River) increases. Thus, in its current unstressed state, the level of the water surface in the aquifer is controlled more by the elevation of the discharge points than by the amount of recharge. Because of these conditions, and as the available record indicates, it is assumed that the long-term change in storage is zero. The records available for January 15, 1975, through January 15, 1976, indicate

TABLE II-14

GROUND WATER IN STORAGE IN THE BIRD'S NEST AQUIFER
TRACTS U-a AND U-b, UINTAH COUNTY, UTAH

<u>Saturated thickness*</u> <u>meters (feet)</u>		<u>Area**</u> <u>hectares (acres)</u>		<u>Ground Water in Storage***</u> <u>10⁶m³ (acre-ft)</u>	
+107	(+350) [probably 114 m (375 ft)]	238.5	(588.8)	7.27	(5,890)
+99	(+325)	194.4	(480.0)	5.92	(4,802)
+84	(+275)	285.1	(704.0)	8.69	(7,042)
+69	(+225)	409.5	(1,011.2)	12.48	(10,114)
+53	(+175)	819.1	(2,022.4)	24.95	(20,226)
+38	(+125)	681.7	(1,683.2)	20.76	(16,833)
23	(75)	629.9	(1,555.2)	14.39	(11,664)
8	(25)	518.4	(1,280.0)	3.95	(3,200)
0	0	365.5	(902.4)	0	0
Total		4142.0	(10,227.2)	98.40	(79,771)

*If the value of thickness is preceded by a +, it includes artesian head and 30 meters (100 ft) of saturated thickness. If the value is less than 30 m, it represents the actual saturated thickness under water table conditions.

**Area determined by planimetry between contours on tract as shown on Figure II-56 (Sect. II.C.2.a).

***For artesian head conditions, a storage coefficient of 1.8×10^{-5} was used; for the saturated aquifer, a specific yield value of 0.1 was used.

that the average net change of water levels in all wells monitored in the bird's nest aquifer was approximately +0.3 m (1.0 ft), including both artesian and water table responses.

h. Ground Water Quality

Austin and Skogerboe (1970) included a comprehensive discussion of ground water quality throughout the Uinta Basin. Table II-15 summarizes the ground water data available in that report and describes waters of the Mesa Verde, Wasatch, Green River, and Uinta formations in terms of total dissolved solids (TDS). According to the available data, the Green River Formation consistently contains water with the lowest TDS content of all the formations. As shown in Figure II-85, the water quality is best near the periphery of the basin and gradually deteriorates toward the central part of the basin.

Feltis (1968) suggested that as indicated by good water quality from rainfall and snowmelt recharge, the main area of aquifer recharge was along the northern and northwestern part of the basin. Not all these aquifers crop out in these areas and therefore are not subject to direct recharge. According to Feltis, these areas of high-quality water are a result of interformational leakage. Electric well-log data indicate that throughout the regional area of this investigation the water-bearing zones of the Mesa Verde, Wasatch, and Green River formations appear to be well isolated from one another by shales. The subsurface extent of fracturing is not known, but surface fracture patterns are continuous through the upper Green River and Uinta formations. If fracturing is continuous into the lower formations, hydraulic communication is possible.

Ground water in the regional area varies in boron content, sodium absorption ratio (SAR) and salinity hazard. Based on the available data (Price and Miller 1974) the following values apply for the immediate vicinity of the tracts.

<u>Location</u>	<u>*Sodium Absorption Ratio</u>	<u>*Salinity Hazard (micromhos/cm)</u>	<u>Boron (mg/l)</u>
10S/21E-16	99 (very high)	3,080 (very high)	--
11S/24E-08	49 (very high)	1,820 (high)	--
11S/24E-31	75 (very high)	1,490 (high)	.29
11S/24E-06	60 (very high)	1,800 (high)	--

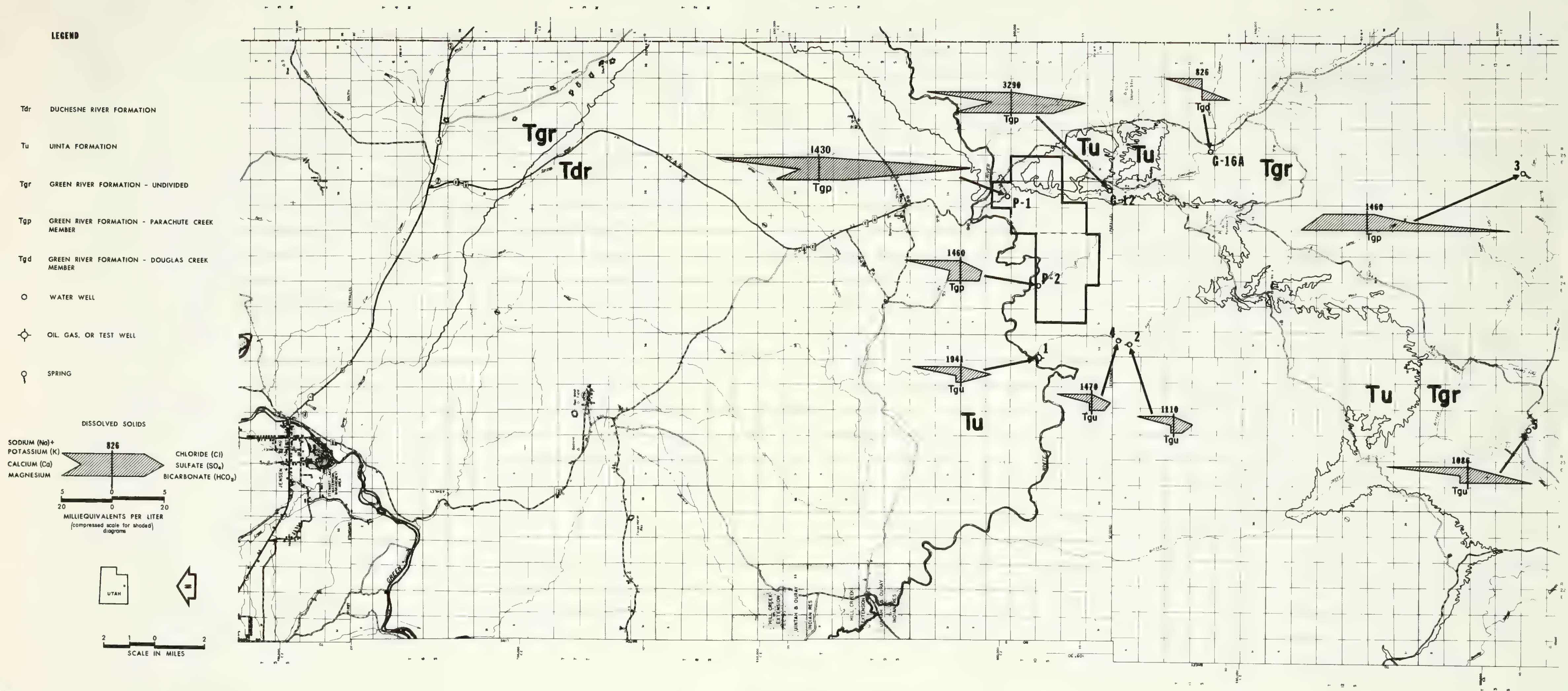
* Based upon irrigation water classification of the U.S. Salinity Laboratory Staff, 1954

TABLE II-15

GROUND WATER QUALITY DATA
IN THE UINTA BASIN, UTAH

<u>Formation</u>	<u>Location (T/R)</u>	<u>Source</u>	<u>Yield (GPM)</u>	<u>Total Dissolved Solids (ppm)</u>
Mesa Verde	9S/23E	-	-	12,511 - 62,502
	10S/24E (2)	Oil Well	1	
	12S/14E	Oil Well	-	
	17S/17E	Spring	-	707
	20S/20E (2)	Oil Well	-	660 - 1,090
Wasatch Formation	15S/21E	-	225 (Sept. 1948)	1,966
	1N/1E (USM)	-		1,302
	16S/17E	Spring		596
Green River Formation	11S/12E	Gas Well)	0.5 - 220 gpm	619
	14S/20E	Oil Well)		818
	15S/23E	Spring)		381
	2N/2W (USM)	Oil Well)		348
				(from 4,115 ft)
	10S/20E-35	Gas Well	80 (flow)	-
	10S/22E-17	Gas Well	10 (flow)	-
	*9S/24E	Oil Well	220	-
				(from 1,932 ft)
Uinta Formation	7S/22E	Oil Well	-	2,365
	7S/24E	Oil Well	110	898
	9S/23E	Oil Well	30	81,200
	4S/5W (USM)	Oil Well	30	22,915
	1S/8W (USM)	Spring	50	237
	4S/7W (USM)	Spring	20	7,320
	5S/6W (USM)	Spring	200	1,840
	5S/7W (USM)	Spring	225	2,710
	2S/5W (USM)	Water Well	-	439
	3S/3W (USM)	Water Well	20	788
	3S/8W (USM)	Water Well	-	4,430

*Largest reported yield from the Green River formation in the Uinta Basin (Austin & Skogerboe, 1970).



STIFF DIAGRAMS OF REGIONAL GROUND WATER QUALITY

FIGURE II-85

According to these data the ground water is poor to marginal for most irrigation uses. In general, the best water is from the Book Cliffs area south of the tracts.

The baseline data collection program yielded a great deal of ground water quality information, and a comprehensive list of constituents was determined for each sample (tables II-16 and II-17). The ground waters for which chemical-quality data are available are those gathered during the baseline period from the bird's nest aquifer; the Douglas Creek Member; and the alluvium of Evacuation Creek, Southam Canyon, Asphalt Wash, and the White River.

The bird's nest aquifer contains water of both qualities, both differing in TDS concentrations. The qualities differ along a diagonal line, or zone, from the vicinity of P-3 on Tract U-b northwest to Tract U-a on the east side of G-5 (Figure II-86). Possible explanations for this are as follows:

1. There may be an undetermined retardant to ground water flow in this area.
2. Aquifers underlying the bird's nest may be contributing a better quality of water by upward leakage.
3. There may be hydraulic communication with, and flushing action by, the White River.
4. The same system of recharge and discharge that now occurs in Evacuation Creek Canyon on and near Tract U-b must have existed far up the canyon at different times and locations as the creek was down-cutting. This would have moved the entry points for recharge water down-dip across Tract U-a, which would have dissolved away much of the nahcolite under Tract U-a without doing so under Tract U-b.
5. Water being recharged into the bird's nest aquifer in this area principally by inflow from Evacuation Creek is subject to oxidation upon entry into the aquifer and subject to reduction as its time in the aquifer increases. This relationship may be seen in the tables by examining the sulfide-sulfate and ammonia-nitrate concentrations in the water of the bird's nest aquifer northeast and southwest.

The last two are the most plausible explanations in view of the foregoing discussions of flat hydraulic gradient and a 50-fold higher transmissivity under Tract U-a, but any combination of these explanations could account for this phenomenon. In any event the water west of the diagonal line is a sodium-sulfate-bicarbonate ($\text{Na-SO}_4\text{-HCO}_3$)

TABLE II-16
SUMMARY OF ALLUVIAL GROUND WATER QUALITY

MARCH 24, 1975 TO AUGUST 22, 1976

Parameters	White River Alluvium Well Numbers AG-1AU, AG-1AL, AG-2U, AG-2L, AG-3U, AG-3L					Evacuation Creek Alluvium Well Numbers G-13A, G-18A, AG-8					Southern Canyon Alluvium Well Number AG-6					Asphalt Wash Alluvium Well Number AG-4					
	No. of Samples	Mean	S.D.	Max.	Min.	No. of Samples	Mean	S.D.	Max.	Min.	No. of Samples	Mean	S.D.	Max.	Min.	No. of Samples	Mean	S.D.	Max.	Min.	
GENERAL																					
Alkalinity Tot	23	344	114	510	171	21	439	330	1530	43	6	280	24.3	305	234	6	477	53.6	556	428	
Dissolved Solids	22	1540	1230	3949	501	19	3820	627	4580	2740	6	7320	412	8013	6950	6	1320	265	1690	1010	
Hardness Tot	23	570	450	1590	76	20	1020	290	1500	400	6	3250	160	3400	3000	6	240	90	380	190	
Non-Carbonate Hardness	23	275	330	1158	0	20	710	280	1400	0	6	2850	185	3196	2700	6	0	0	0	0	
Oil and Grease	12	2	6	6	0	13	3	5	19	0	2	1	1.4	2	0	2	1	1.4	2	0	
pH field	23	7.6	53	8.3	6.2	12	8.1	0.4	8.8	7.3	6	7.6	31	8.0	7.2	6	8.0	0.15	8.1	7.8	
Specific Conductance	23	1850	1325	4000	480	20	4650	1075	8000	3100	6	6450	500	7000	5600	6	1850	440	2600	1400	
Temperature	23	9.7	2.0	12.7	5	19	12.1	5.9	32.2	5.0	6	11.5	1.5	13.0	8.7	6	12.1	1.35	13.9	10	
Turbidity	6	650	920	2500	80	0	—	—	—	—	0	—	—	—	—	0	—	—	—	—	
MAJOR CATIONS																					
Calcium	23	112	74	268	12	21	205	107	580	98	6	660	50	728	600	6	18	5.7	26	11	
Magnesium	23	67	66	220.8	11	21	124	80	200	0.2	6	380	15	400	360	6	48	19	77	30	
Potassium	23	3.9	1.0	6.0	2.2	21	1.2	5.0	25	6.4	6	6.6	1.0	8.2	5.5	6	2.1	0.5	2.9	1.5	
Sodium	23	270	210	619	60	21	790	120	1080	550	6	890	150	1146	730	6	370	62	460	300	
SAR	23	4.6	3.3	11	6	20	11	17	14	6.3	5	6.1	52	6.8	5.5	6	10	1.1	11	8	
% Sodium	17	50	18	85	31	20	63	6.8	77	45	3	35	2.4	38	32	5	77	4.0	81	72	
Sr/Strontium	17	1500	910	3400	410	15	2950	925	4300	1300	5	7600	2700	11,000	4500	5	875	230	1200	610	
MAJOR ANIONS																					
Bicarbonate	23	419	140	622	209	21	399	276	1160	0	6	341	29.6	372	285	6	582	653	678	522	
Carbonate	23	17	0	0	0	19	5.3	12	38	0	6	0	0	0	0	6	0	0	0	0	
Chloride	23	91	59	232	26	21	53	13	93	33	6	230	37	280	170	6	51	10	69	40	
Sulfate	23	660	680	2150	81	21	2200	550	3020	1000	6	4300	520	5290	3800	6	460	135	650	300	
Silicate	23	14	3.5	14	0.00	18	0.2	0.8	3.5	0.0	6	53	1.3	3.2	0	5	0.5	1.3	3.2	0	
Fluoride	22	9	75	2.6	2	21	0.80	36	154	0.2	6	7	4	14	4	6	3.8	2.1	5.8	0.7	
Bromide	22	9	75	2.6	2	21	0.80	36	154	0.2	6	7	4	14	4	6	3.8	2.1	5.8	0.7	
BIOCHEMICAL																					
Carbon Dioxide	6	62	29	92	26	14	75	46	180	30	2	25.5	15	36	15	2	23.5	16	35	12	
COD	8	> 9	2	> 5	0	1	> 5	> 5	> 5	> 5	0	25	35	5	—	1	> 5	> 5	> 5	> 5	
SOC	0	—	—	—	—	11	30	14	60	13	0	—	—	—	—	0	—	—	—	—	
DOC	0	—	—	—	—	4	289	320	757	44	0	—	—	—	—	0	—	—	—	—	
TIC	22	12	10	39	2.0	8	17	5.5	29	9	6	6.2	1.9	11	6	6	1.3	3.9	19	9	
MACRO NUTRIENTS																					
Ammonia	17	46	19	74	20	19	0.18	0.26	1.1	0.03	5	0.6	0.5	14	0.1	5	0.03	0.02	0.06	0.00	
Nitrate	17	0.1	0.4	16	0.15	19	0.25	0.35	0.77	0.00	6	24	11	38	12	6	0.02	0.03	0.06	0.00	
Nitrite	17	0.1	0.9	26	0.1	19	0.29	0.34	1.5	0.00	6	6.1	2.5	8.5	1.66	6	4.9	2.9	9.3	2.2	
Kjeldahl Nitrogen	23	4.1	3.9	17	0.77	19	2.5	2.6	10	0.62	5	1.5	1.2	3.3	6.3	6	1.89	0.78	3.08	0.98	
Orthophosphate	17	0.2	0.3	10	0.00	20	0.02	0.03	0.11	0.00	5	0.2	0.2	0.4	0	6	0.03	0.01	0.05	0.01	
Total Phosphorus	17	2.2	2.9	9.7	0.9	20	0.92	1.9	7.4	0.0	6	2.0	3.3	8.7	19	6	0.32	0.20	0.57	0.07	
MICRO NUTRIENTS																					
Boron	17	1100	1200	4400	30	20	1020	900	2700	30	5	600	360	1200	250	5	1540	1270	3700	540	
Copper	17	3	2.5	11	1	17	27	35	130	1	5	8	6.6	18	2	5	18	7.3	30	12	
Iron	17	110	180	650	1	19	35	25	100	0	5	26	13	40	10	5	34	25	70	10	
Manganese	17	280	160	470	20	18	250	400	1200	0	5	2480	480	3300	2100	5	14	7	30	10	
Zinc	17	70	200	860	0	17	19	22	90	0	6	3000	1750	4600	260	5	16	15	40	0	
Molybdenum	17	11	12	40	0	16	60	58	250	22	5	3.8	3.6	7	0	5	430	120	530	230	
Cobalt	17	0	0	0	0	18	0.9	1.8	7	0	5	1.3	3	3	0	5	0	0	0	0	
Silica	17	18	2.7	23	1.3	21	7.7	4.5	17	0.7	5	20	84	21	14	6	11	4.6	14	1.8	
TRACE METALS																					
Aluminum	17	25	20	60	0	16	24	11	50	0	5	20	7	30	10	5	32	18	50	10	
Barium	17	65	100	300	0	1	800	600	800	800	5	80	180	400	0	5	40	55	100	0	
Beryllium	17	20	4	7	0	17	< 7	6	20	0	5	10	10	20	0	5	< 34	> 45	< 25	< 25	
Bismuth	17	< 35	< 30	< 85	< 10	9	< 80	35	< 120	< 10	5	< 50	> 11	< 160	< 130	5	< 8.2	> 45	< 45	< 45	
Cadmium	23	< 2	57	180	5	18	0.1	1	1	0	5	1.4	17	4	0	5	< 0.6	0.9	< 2	< 2	
Chromium	17	< 40	40	< 180	< 5	8	< 60	10	< 80	< 50	5	< 100	> 5.6	< 100	< 100	6	< 23	> 2	< 35	< 35	
Gallium	17	< 12	9	< 30	< 10	8	< 100	30	< 170	< 70	5	< 170	> 32	< 200	< 130	5	< 38	> 8.5	< 50	< 10	
Germanium	17	< 45	35	< 30	< 10	8	< 100	30	< 170	< 70	5	< 170	> 32	< 200	< 130	5	< 38	> 8.5	< 50	< 10	
Lead	17	6	19	78	0	18	< 100	3.7	14	0	5	2.6	37	9	0	5	< 2	> 3.5	< 8	< 8	
Lithium	17	55	40	130	10	18	118	24	160	80	5	40	2	40	40	5	170	37	230	140	
Mercury	21	1	15	5	0	19	1	14	4	0.0	6	2	2	5	0	6	0.2	0.3	0.7	0.0	
Selenium	15	0	0	0	0	16	2	2	7	0	5	38	13	55	18	5	5.8	5.1	11	0	
Silver	17	0	0	0	0	20	0	0	0	0	5	0	0	0	0	5	0	0	0	0	
Tin	17	< 30	25	< 100	< 10	8	< 75	20	< 100	< 50	5	< 110	> 22	< 150	< 100	6	< 26	> 16	< 45	< 45	
Titanium	17	< 20	15	< 50	0	8	< 45	12	< 30	< 30	6	< 75	> 25	< 100	< 45	6	< 21	> 13	< 33	< 10	
Vanadium	17	3.4	2.2	8.3	0.2	20	0.9	1.0	4.1	0.0	5	4.4	1.1	5.8	2.8	5	3.4	13.0	8.0	< 19	
Zinc	17	< 55	40	< 130	< 20	8	< 110	30	< 150	< 70	5	< 175	> 25	< 200	< 150	5	< 54	> 27	< 100	< 30	

TABLE II-16 (continued)

	White River Alluvium Well Numbers AG-1AU, AG-1AL, AG-2U, AG-2L, AG-3U, AG-3L						Escalation Creek Alluvium Well Numbers G-13A, G-18A, AG-8						Souiham Canyon Alluvium Well Number AG-6						Asphalt West Alluvium Well Number AG-4					
	No. of Samples	Mean	S.D.	Max.	Min.		No. of Samples	Mean	S.D.	Max.	Min.		No. of Samples	Mean	S.D.	Max.	Min.		No. of Samples	Mean	S.D.	Max.	Min.	
TRACE																								
Arsenic µg/l	15	6	4	11	0		19	1.2	1.0	3	0		5	1.4	0.9	2	0		5	8	2.2	11	5	
Cyanide mg/l	23	0.01	0.03	0.1	0		9	0.02	0.04	0.1	0.00		6	0.02	0.04	0.1	0		6	0.02	0.04	0.1	0.00	
Phenols µg/l	12	1	1	3	0		3	1.3	1.5	3	0		2	5	7	1	0		2	0.5	0	1	0	
Pesticides µg/l	1	0	0	0	0		1	0	0	0	0		1	0	0	0	0		1	0	0	0	0	
Herbicides µg/l	1	0	0	0	0		1	0	0	0	0		1	0	0	0	0		1	0	0	0	0	
Cesium 137 Dis PC/l	0	>20	>18	<49	<6		0	—	—	—	—		0	<100	0	<100	<100		0	—	0	—	—	
Gross A Dis U-Na µg/l	6	—	—	—	—		0	—	—	—	—		1	<100	0	<100	<100		1	50	0	50	—	
Gross A Dis U-Na µg/l	12	<4.3	>3.6	9.8	1.0		0	—	—	—	—		2	<12	<15	<23	1.2		0	3	—	6.4	1.0	
Gross B Dis Co-137 PC/l	0	—	—	—	—		0	—	—	—	—		0	<19	0	<19	<19		0	—	—	—	—	
Gross B Dis Sr-90 Y-90 PC/l	6	<6.0	>2.0	<6.3	3.6		0	—	—	—	—		1	<19	0	<19	<19		1	5.3	0	5.3	5.3	
Gross B Dis Sr-90 Y-90 PC/l	0	—	—	—	—		0	—	—	—	—		0	—	—	—	—		0	—	—	—	—	
Potassium 40 Dis PC/l	6	3.1	0.9	4.3	1.7		3	7.8	0.3	8.0	7.5		0	5	0	5	5		1	1.5	0	1.5	1.3	
Ra 226 BY Rn PC/l	4	<0.7	>0.5	12	<0.1		2	0.65	0.07	0.7	0.6		0	—	—	—	—		1	0.9	0	0.9	0.9	
Residue Tot. Flt. 105°C mg/l	6	1500	1320	3600	510		0	—	—	—	—		0	7300	0	7300	7300		0	1100	0	1100	1100	
U Dis PC/l	0	—	—	—	—		0	—	—	—	—		1	7300	0	7300	7300		0	—	—	—	—	
U Dis Dir Flour µg/l	4	18	1.0	2.9	0.5		2	18	2.6	20	16		0	—	—	—	—		0	—	—	—	—	
U Dis Nat µg/l	0	—	—	—	—		0	—	—	—	—		0	—	—	—	—		1	15.0	0	15.0	15.0	
RADIOACTIVE CONSTITUENTS																								

TABLE II-17
SUMMARY OF GROUND WATER QUALITY
OCTOBER 18, 1974 TO SEPTEMBER 20, 1976

Parameters	Bird's Nest Aquifer (NE) Well Numbers P-1, G-9, G-8A, G-10, G-11, G-12, G-14					Bird's Nest Aquifer (SW) Well Numbers P-2L, P-3, G-5, G-15, G-21					Upper Aquifer Well Number P-2U					Douglas Creek Aquifer Well Numbers P-4, G-16A				
	No. of Samples	Mean	S.D.	Max.	Min.	No. of Samples	Mean	S.D.	Max.	Min.	No. of Samples	Mean	S.D.	Max.	Min.	No. of Samples	Mean	S.D.	Max.	Min.
GENERAL CHARACTERISTICS																				
Alkalinity, Tot	47	616	383	1970	216	39	934	559	3010	240	12	510	34	554	434	9	675	136	817	482
Dissolved Solids	41	4030	959	6000	1430	36	1760	769	4350	878	12	2650	4350	3200	1460	10	919	3200	1090	826
Hardness, Tot	42	1000	330	1500	250	37	69	59	200	0	12	276	55	370	180	9	45	59	140	2
Non-Carbonate Hardness	43	480	340	980	0	32	0	0	0	0	10	0	0	0	0	9	0	0	0	0
Oil and Grease	42	2.5	4	21	0	38	3.5	4.5	24	0	10	5.5	12	39	0	9	1.6	1.5	4	0
pH, field	41	7.9	7	11.4	7.3	41	9.0	7	10.7	7.4	10	8.1	2	8.5	7.9	11	9.4	8.5	10.9	8.0
Specific Conductance	47	4700	1170	6900	1130	42	2510	1030	5300	300	12	3280	800	4200	1810	12	1470	162	1720	1300
Temperature °C	39	—	—	—	—	39	16.3	1.5	19.5	12.8	11	15.3	1.0	17.5	13.5	10	13.0	1.4	15.3	10.3
Turbidity Jtu	0	—	—	—	—	0	—	—	—	—	0	—	—	—	—	0	—	—	—	—
MAJOR CATIONS																				
Calcium, Dis	47	130	64	210	5.7	37	9.0	13	75	1	12	28	4.8	36	19	9	3.8	4.0	10	7
Magnesium	44	170	40	260	67	41	11	98	30	3	12	49	12	68	30	9	8.2	11.4	27	9
Potassium	43	7.2	2.7	13	2.3	41	2.6	1.5	8.1	1.2	12	3.0	0.6	11.0	1.8	9	2.6	1.7	1.8	4.5
Sodium, Dis	42	890	270	1800	310	41	640	300	1700	300	12	776	156	940	31	9	356	31	430	320
SAR	43	13	7.8	52	1.8	37	59	58	245	14	12	20	2.7	23	14	9	2.7	53	35	104
% Sodium	43	64	12	98	34	37	95	49	100	84	12	86	2	88	7	9	84	7	100	83
Strontium	40	7100	3200	19,000	2200	37	1400	1200	4800	60	12	4550	1000	6400	2600	11	1700	2280	5000	40
MAJOR ANIONS																				
Bicarbonate	47	681	467	2400	216	42	814	328	1710	201.6	12	622	42	675	529	9	657	79	753	510
Carbonate	47	4	19	117	0	41	147	220	1160	0	12	0	0	0	0	9	81	53	138	0
Chloride	47	75	37	280	36	36	130	160	580	31	12	59	12	82	36	9	37	102	230	68
Sulfate	47	2150	790	3300	180	36	400	220	1200	23	12	1360	370	1800	730	9	370	48	130	13
Fluoride	43	19	35	150	0	37	68	78	340	10	5	4	8	18	1	9	3.1	4.2	10	0
Bromide	43	17	2.2	11	2	40	3.0	3.9	21	9	12	6	3	1.1	4	9	13	6	2.4	9
	12	1.4	2.6	9.3	3	9	2	2	6	0	3	.5	4	9	2	3	2	3	6	0
BIOCHEMICAL CONSTITUENTS																				
Carbon Dioxide	38	22	17	81	0	37	5.1	10.5	61	0	11	8.4	3.6	14	3.3	8	2.3	3.5	9.4	0.0
COD	47	85	120	760	4	41	143	103	370	6	10	23	22	79	6	9	90	98	260	6
SOC	0	—	—	—	—	0	—	—	—	—	0	—	—	—	—	0	—	—	—	—
TOC	31	20	16	66	4.6	27	15	14	66	2.3	7	7.9	6.6	43	3.0	7	26	27	57	3.1
TIC	23	61	89	378	0	13	78	113	386	0	4	156	125	258	0	4	125	87	176	0
DOC	9	15	10	34	5.0	5	11	9.3	22	2.9	1	1.7	0	1.7	1.7	2	10.1	9.8	17	3.2
MACRO NUTRIENTS																				
Ammonia	42	78	86	2.9	0.0	35	1.6	1.7	8.1	43	11	1.9	76	3.9	5.3	9	1.7	1.1	3.5	65
Nitrite	42	01	02	09	0.0	35	006	01	04	00	11	01	.01	04	00	9	004	004	02	00
Nitrate	35	05	11	51	0.0	35	018	04	74	.00	11	01	01	04	00	9	.03	004	10	00
Kjeldahl Nitrogen	43	1.7	1.6	7.7	0.5	37	2.7	3.5	18	51	11	2.2	1.2	5.0	64	8	1.2	1.6	4.7	72
Orthophosphate	47	04	07	40	0.0	39	00	13	47	00	11	.02	.02	05	01	9	.11	.05	20	05
Total Phosphorus	47	13	30	1.4	.00	41	17	.20	.90	00	11	.03	.02	06	00	9	.15	.05	23	08
MICRO NUTRIENTS																				
Boron	43	5500	13,000	78,000	30	36	3200	4800	36,000	400	12	375	230	1100	180	11	2010	2340	5200	80
Copper	39	2.5	3.7	19	0	37	1.40	1.0	7.30	0	12	1.8	2.6	7	0	11	<2.6	3.9	14	0
Iron	43	680	1000	4600	20	37	140	110	730	5	12	110	80	280	10	11	<80	48	180	30
Manganese	43	60	60	230	0	40	30	40	250	0	11	45	30	130	20	11	<8.5	6	20	0
Zinc	43	70	90	480	0	37	30	50	280	0	12	20	20	80	0	11	<15	10	30	0
Molybdenum	43	56	72	280	0	36	8	24	140	0	11	30	21	74	11	11	<4.7	85	280	0
Cobalt	42	1.5	2	9	0	36	<3	5	<55	0	11	<3	4	<16	0	11	<2.5	3.3	<8	0
Silica	47	16	6.6	28	7.4	35	15	5.4	27	3.3	12	1.9	2	21	17	9	11.4	4.6	20	7.9
TRACE METALS																				
Aluminum	39	35	60	290	0	40	<30	30	140	0	11	13	10	30	0	11	21	22	70	0
Barium	47	<55	45	100	0	36	<120	140	600	0	11	<48	44	100	0	11	145	120	400	0
Beryllium	43	<8	6	20	0	36	<6	5	20	0	11	<7	7	20	0	11	<4.4	6.4	20	0
Bismuth	37	<45	32	<120	<3	27	<24	18	<80	<7	8	<32	26	<80	<15	9	<11.5	9.5	<30	<6
Cadmium	43	1	3	1	0	36	1	3	1	0	11	0	0	0	0	0	0	0	0	0
Chromium	39	<20	25	<85	0	36	<10	9	<55	<60	10	<12	18	<60	0	0	—	—	—	—
Gallium	37	<17	11	<40	<1	27	<10	8	<30	<3	8	<11	6	<20	<7	9	<4.5	2	<8	<3
Germanium	37	<55	45	<180	<3	31	<32	32	130	0	8	<40	37	<120	<10	9	<2.5	3.5	<8	<6
Lead	41	9	15	7	0	36	1	1	4	0	11	<3	4	<16	0	11	<320	380	720	100
Lithium	41	470	380	1400	140	37	510	200	960	230	12	320	44	380	240	11	<320	380	720	100
Mercury	40	<6	9	4	0	37	1	5	2.8	0	12	<.02	04	10	00	9	<0.3	04	<1	0
Selenium	43	2.5	5	22	0	37	1	5	2	0	12	1.5	3	1.0	0	0	<3	5	<1	0
Silver	43	<2	4	1	0	36	06	.2	1	0	11	<.15	6	<2	0	11	<9	7	<20	<6
Tin	37	<42	27	<85	<3	27	<23	14	<60	<7	8	<32	19	<60	<15	9	<9	4	<9.2	0
Titanium	37	<30	18	<70	<3	26	<16	11	<40	<4	8	<21	15	<50	<8	11	<3	4	9.2	0
Vanadium	42	1.8	1.8	6.4	0	36	<2.7	4.0	20	0	11	8	6	1.9	0	9	<3	4	9.2	0
Zirconium	37	<70	50	<200	<5	27	<38	30	<130	<9	8	<55	40	<120	<15	9	<18	11	<40	<9

water with an average TDS of 2540 mg/l; east of the diagonal the water is also a Na-SO₄-HCO₃ water but with an average TDS of 3298 mg/l. Oxidation reduction chemistry is discussed further in Surface Water Hydrology, in the discussion of the water quality of Evacuation Creek.

In most of the wells the water chemistry of the bird's nest aquifer fluctuated widely from sample to sample, probably as a result of the differences in sampling and in laboratory analysis rather than as a result of naturally occurring chemical changes. At most well locations, the bird's nest water is charged in varying degrees with hydrogen sulfide gas. Samples of pumped water have been collected at the well head in glass jars and allowed to stand exposed to the atmosphere. Within minutes, flocculation and precipitation has begun and the pH has risen from the original range, 7.5 to 8.5, to a range of 10 to 11. It is known that rapid chemical changes can occur, and therefore in-line filters (on the pump discharge line) were used in the November-December 1975 sample collections to minimize the exposure time to the air. All other sample preparation procedures, such as using preservatives and chilling, were followed as before.

Thiefed, or static, samples were collected from time to time in some wells when the pumping equipment was not functioning. The water chemistry analyses of actual concentrations of samples collected in this manner show little resemblance to that of pumped samples, although the ionic ratios remained about the same. The different chemistry of water samples collected at various times from P-1 by the two methods are shown on Table II-18. Changes similar to those that take place in a sample exposed to air are apparently occurring under static conditions in the borehole.

Pursuant to the November 26, 1975, and January 26, 1976, Conditions of Approval, ten alluvial wells were installed at eight locations in drainages on and adjacent to Tracts U-a and U-b. In addition, two alluvial wells (AG-3 lower and AG-6) installed by the USGS were incorporated into the alluvial well program. In all, ten alluvial wells contained water and were sampled for water chemistry and measured monthly for water level, as prescribed in the Conditions of Approval. Two of the wells, AG-5 in upper Asphalt Wash and AG-7 in upper Southam Canyon, were dry when drilled and remained dry from January through September 1976.

January and June 1976 were the two months in which all of the alluvial wells were to be sampled. For this report June was arbitrarily chosen as the month for comparing water quality samples from the different wells, as seen on Figure II-87.

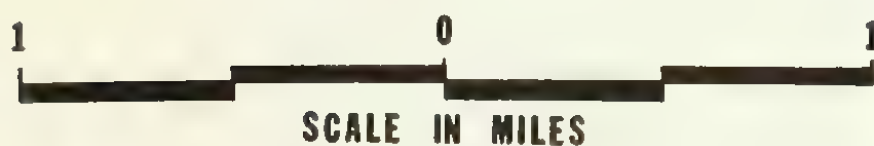
LEGEND

NOTE: NUMBER AT TOP OF FIGURE IS TOTAL DISSOLVED SOLIDS IN MG/L.

STIFF DIAGRAM SCALE



- S SURFACE WATER MONITORING STATION
- P PILOT TEST HOLE (WATER)
- G GROUND WATER MONITORING STATION
- HE EXISTING GEOLOGIC CORE HOLE, EVACUATION
- HS EXISTING GEOLOGIC CORE HOLE, SOUTHAM
- X EXPLORATION GEOLOGIC CORE HOLE
- AG ALLUVIAL WELL (WATER)
- △ AR PRECIPITATION, AUTO (WATER)
- ▲ RS PRECIPITATION, STORAGE (WATER)
- * EVP EVAPORATION PAN (WATER)

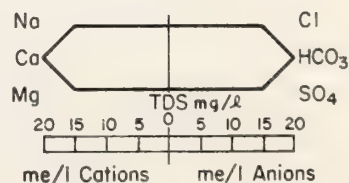
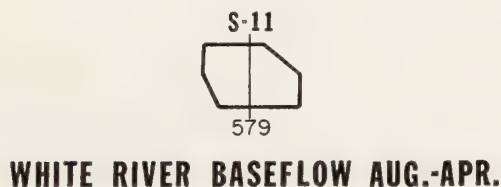
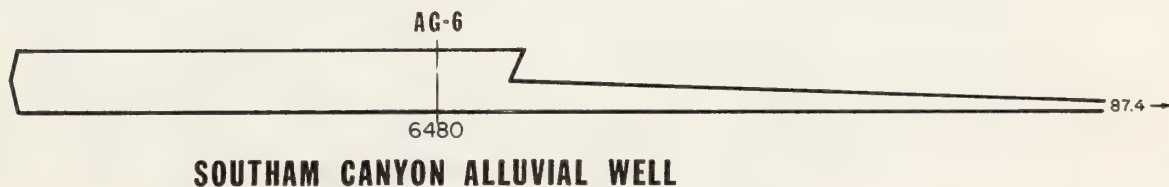
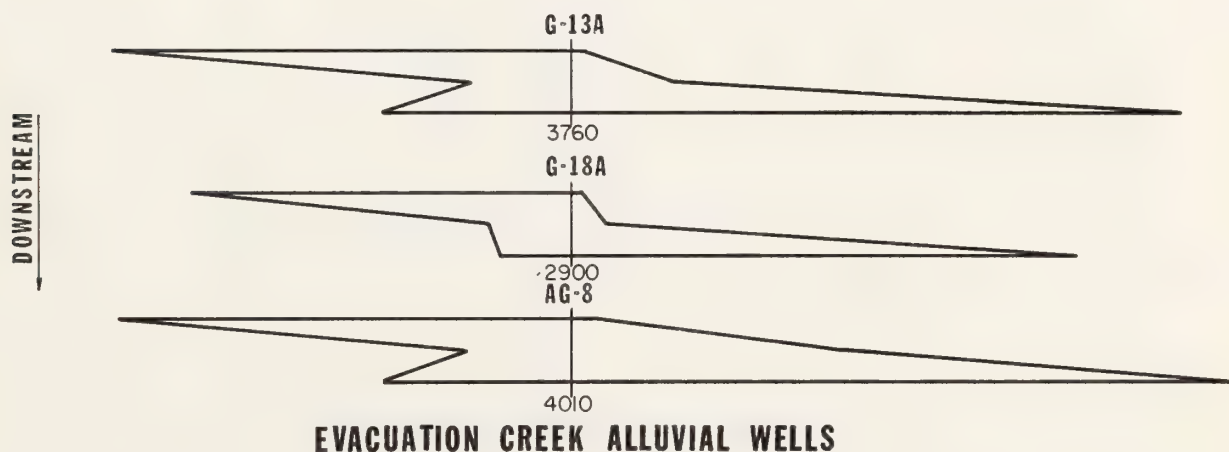
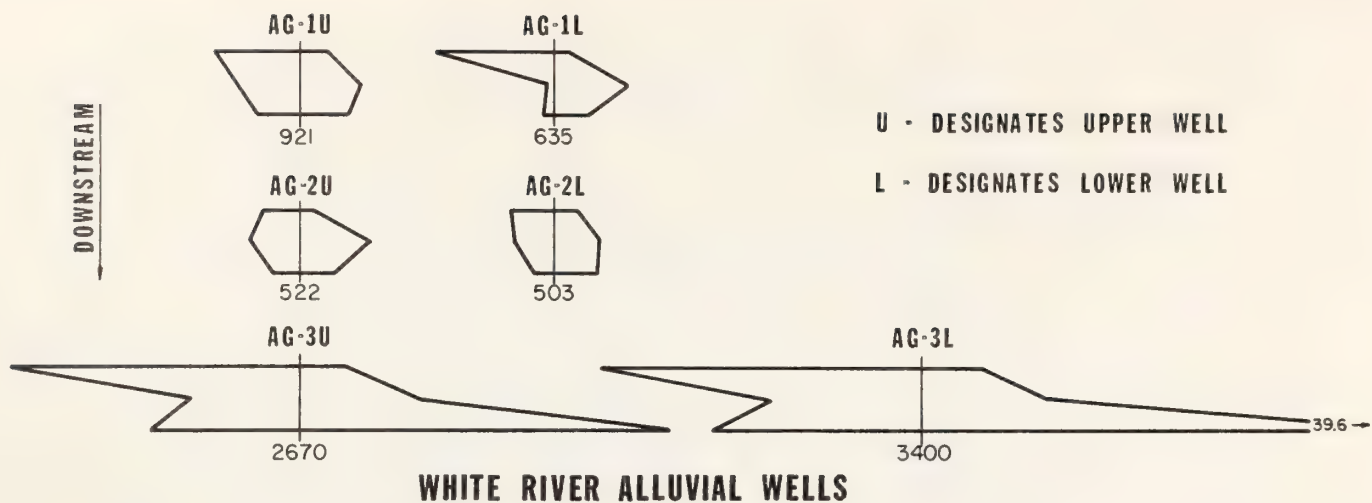


WHITE RIVER SHALE PROJECT
STIFF DIAGRAMS OF WATER QUALITY
MEAN OF ALL SAMPLES NOVEMBER 1974 - NOVEMBER 1976
TRACTS U-a-Ub, EASTERN UINTA, UTAH

TABLE II-18
COMPARISON OF BIRDS NEST PARTIAL WATER QUALITY
DIFFERENCES BETWEEN PUMPED AND STATIC SAMPLES
AT THE P-1 SITE

Date	Specific Conductance ($\mu\text{mho}/\text{cm}^2$)	Total Filtrable Residue (mg/l)	Bicarbonate (mg/l)	Calcium (mg/l)	Magnesium (mg/l)	Sodium (mg/l)	Chloride (mg/l)	Sulfate (mg/l)	TDS (mg/l)
Nov. 20, 1974	5100	4600	543	170	170	930	58	2400	4430
*Dec. 17	1810	1400	303	64	67	310	38	780	1430
Mar. 18, 1975	5200	4800	522	170	190	910	59	2700	4320
May 13	5100	4950	545	170	190	910	56	2500	4350
June 26	4870	4800	536	170	190	910	60	2500	4470
Aug. 17	5170	4800	540	170	210	940	59	2700	4360
Aug. 30	4600	--	453	180	190	940	59	2800	4450
Nov. 14	4750	--	551	130	170	900	62	2400	4380

*December 17, 1974 represents thieved sample. All others collected by pumping.



ALLUVIAL GROUND WATER QUALITY **WHITE RIVER SHALE PROJECT - JUNE 1976**



In discussing the quality of alluvial water in the vicinity of the tracts it is important to note that precipitation is low in the area and that the exposed formations tend to contain sufficient salt to form white precipitate or efflorescence at points of seepage along bedding and fracture planes. Large quantities of the white precipitate ultimately enter the alluvial channels during runoff events. Most of the channels monitored and their side channels seldom contain water on their surfaces. It would seem that alternate light wetting, minor inflows, and drying would tend to concentrate salts in the alluvial channels. This is substantiated by the presence of white encrustation at various times and places in the alluvial channels. It would follow that the water quality of an alluvial well located to receive underflow or surface runoff and deep percolation from such an alluvial channel would be influenced to some degree.

As may be determined from the Stiff diagrams, the quality of water in the alluvium at the three White River locations--AG-1, AG-2, and AG-33--is quite variable. There is no concrete evidence as to the reason for this variability, only some general observations, as follows:

At the AG-1 site, opposite and slightly downstream of Hells Hole Canyon, the wells are set in a small alluvial fan extending outward from a large south-draining canyon that has pushed its fan out into the White River at that location. Differences in water chemistry between the upper and lower wells may be in part influenced by deep percolating water from the tributary through the surface of the fan. The lower well, completed on bedrock, may be influenced by some leaching from the bedrock surface. As shown on Figure II-87 the shape of the diagram is very similar to diagrams for the bird's nest aquifer (designated SW) and Douglas Creek aquifer (Figure II-86).

The quality of the alluvial water at the AG-2 site is very similar to that occurring during baseflow on the White River (diagram shown on Figure II-87). The similarity of water quality may be because of the lack of a well defined tributary near the wells, which could bring runoff to them, and also because the wells are nearer the channel of the White River than are those of the AG-1 site.

The alluvial water at the AG-3 site is highly mineralized in comparison with the White River water at that location. On first observation the quality of the alluvial water looks similar to that analyzed from the P-2 upper aquifer location. The P-2 upper aquifer was not penetrated elsewhere on the tracts and was not encountered in X-1, the western-most hole drilled for this project. This is not conclusive evidence that the P-2 upper aquifer does not exist beneath the AG-3 site. Data included on Figure II-72 indicate that well 7

(an oil well off the tracts) encountered the bird's nest aquifer at a depth of 159 m (520 ft); however, there is no indication that the upper aquifer exists at this location. It is interesting that the artesian water surface on the bird's nest aquifer throughout much of Tract U-a is at an elevation of 1479 m (4850 ft) (Figure II-75). Although the top of the aquifer is at an elevation of about 1373 m (4500 ft) under the AG-2 site, if the 1479-m (4850-ft) head elevation persisted to the AG-3 site it would be roughly coincident with the base of alluvium.

The evidence collected concerning the bird's nest aquifer during this investigation suggests that upward leakage is not a factor in these variations, but conclusive data are not available from the bird's nest aquifer in the AG-3 area. Upward leakage and attendant chemical changes could account for the alluvial water chemistry at the AG-3 site. A more plausible explanation for the chemistry difference of stream and alluvial water at this location would be the effects of seepage to the alluvium through the Uinta Formation. Of all the river alluvial well locations, AG-3 is the only one in alluvium truncating the strike of the Uinta Formation. The alluvium being so situated is in an excellent location to receive seepage from bedding and fracture planes in the Uinta Formation. Evidence of seepage may be seen in shallow soils all along the ground leading down from the bedrock ridge east of the well to the alluvial apron.

Well AG-4 is near the mouth of Asphalt Wash and penetrates bedrock at a depth of about 13 m (44 ft). Three test holes were drilled in the area of AG-5, which is upstream of AG-4 on Asphalt Wash. None of the three test holes contained water, and AG-5 was completed in the deepest of the test holes to 24.1 m (79.0 ft). Because no water was encountered upstream at the AG-5 location, the alluvial water at AG-4 may be a mix of White River alluvial water with contribution of salts accumulated in the alluvium.

As part of a regional investigation, the USGS installed two alluvial wells in Southam Canyon upstream of its confluence with the White River. One of these wells, AG-6, the deeper of the two, was incorporated into the alluvial water baseline program. Another well was installed upstream in the drainage near the southern boundary of Tract U-a (AG-7). Three additional alluvial wells upstream of AG-6--G-1A, G-2A, and G-4A--were installed during the initial drilling program in fall 1974. All of these locations are, and have been, dry throughout the period of record.

It is noteworthy that AG-6 is downstream of the site that produced the largest flow rate from the bird's nest aquifer (P-2 lower). During fall 1974 the site was occupied during air-mist drilling of a deep corehole, two pumpholes, and

an observation hole. Water production from the combined upper aquifer and the bird's nest throughout much of the 45-day period was about 26 l/s (400 gpm). Aquifer tests were conducted in both aquifers during summer 1975. All discharges went into the alluvial channel. Two dry alluvial wells are just upstream of the P-2 site (G-1A, G-2A), and thus it is not likely that the AG-6 water is a result of drilling and testing discharges onto the alluvium at the P-2 site.

The quality of water in AG-6 is the poorest (6480 mg/l TDS) of any water from any other source collected during the baseline study. By comparison, the principal discharge from the P-2 site was from the bird's nest aquifer, and the average TDS of that water, as determined from 11 samples collected during the two-year baseline investigation, was about 1430 mg/l. If, in fact, the water at AG-6 is the result of discharges from the P-2 site, the alluvium must have contained high salt concentrations, which must have been leached into solution by down-percolating water.

During the fall 1974 drilling program, two alluvial wells were installed in the Evacuation Creek drainage. These are G-13A, about 5 km (3 mi) upstream of Tract U-b, and G-18A, near the south border of the tract. These wells were sampled regularly during the first 16 months of the baseline program. The November 26, 1975, Conditions of Approval specified that two additional wells be installed--one across the channel from G-18A (AG-9) and the other near stream monitoring station S-2 (AG-8), close to the north border of Tract U-b. Three test holes were drilled in the G-18A area, and none contained more than a few centimeters of water. Well AG-9 was installed in one of the test holes, but G-18A had more saturation and was therefore used for sampling. AG-8 was installed and sampled, and G-13A continued to be sampled. Partial results are included on Figure II-87.

i. Ground Water Use

The ground water from the bird's nest aquifer is of limited use because of its quality. The salinity hazard is extremely high, which generally makes the water unfit for most irrigation applications. The sulfates, hardness, and TDS make the water unsuitable for most industrial and domestic uses without treatment.

Springs and shallow alluvial wells supply users in the southern Uinta Basin with most of their ground water, which is used mainly for stock watering and alternate domestic supplies (Price and Miller 1974). The American Gilsonite Company has drilled about 21 wells in the alluvium of the White

River near the Ignacio Stage Stop. The wells supply water for the gilsonite mining operation and for the residents of Bonanza, Utah. A few deep oil and gas wells near the tracts have been converted to stock-watering wells.

3. INTERPRETATION AND CONCLUSIONS

Several conclusions regarding the interrelationships of surface water and ground water may be drawn from the data. The bird's nest aquifer is known to crop out continuously in the bed of Evacuation Creek from a point about 3.65 km (2.25 mi) south of Tract U-b to the north edge of Tract U-b. Throughout the first 2.4 km to 3.2 km (1.5 mi to 2 mi) the aquifer apparently receives recharge from the stream and its alluvium; beyond that distance the aquifer discharges back to the stream and its alluvium. Most of this discharge passes the S-2 gaging station on Evacuation Creek, where baseflows of 1.42 l/s (0.5 cfs) were recorded during fall 1974, 1975, and 1976. Discharge from the aquifer occurs for about another 0.8 km (0.5 mi) downstream of S-2, and the total discharge may be in the range of 2.84 l/s (0.1 cfs). The flow eventually discharges to the White River.

About 0.8 km (0.5 mi) downstream of the confluence of the White River and Evacuation Creek (Section 12, T10S, R24E) the river channel cuts through the bird's nest aquifer, and the aquifer discharges into the river at this location. This discharge is not of sufficient quantity to be detected in the established flow records at S-1 and S-3, located on the White River upstream and downstream of the discharge point. The water quality records from these stations do not reflect the aquifer water discharged to the river despite the fact that at certain times the TDS concentrations in the ground water are ten times those of the river water.

Another point of hydraulic communication with the bird's nest aquifer may be the Green River where it flows from the Uinta Basin near Ouray, but this interconnection of stream and aquifer has not been established as part of this investigation. The data available do not support interconnection of the bird's nest aquifer and the White River beyond the north edge of Tract U-b, where the aquifer is cut by the river.

Water levels in the alluvium of the White River rose slightly with rising river stage at AG-2 and AG-3, but the same response was not observed at AG-1. Both the upper and lower well water levels at AG-1 have shown a near constant decline from the time they were installed in January 1976 through September 1976. The alluvium at this location is extremely silty, and recovery after sampling is slow. Attempts to

develop these wells with air yielded less than a liter per minute. Although the alluvial material at this location must be hydraulically connected with the river, the low permeability apparently attenuates the effects of changing river stage.

4. EVALUATION OF BASELINE PROGRAM

a. Ground Water Occurrence

Research of literature pertaining to regional ground water resources and intensive site-specific investigations were sufficient to describe the occurrence of ground water within narrow limits above, below, and in the mining zone. Geophysical logs of oil and gas wells confirmed the existence of the bird's nest aquifer in an area several kilometers around the tracts. The similarity of geophysical log characteristics between wells on and off the tracts suggests that the lithology and quality of the contained water is similar.

Although Austin and Skogerboe (1970) reported the occurrence of water in the Uinta Formation elsewhere in the Uinta Basin, the exhaustive drilling programs that have been conducted on Tracts U-a and U-b (nomination drilling, ground water exploration program, and geologic exploration program) have indicated no continuous, high-capacity aquifers or water-bearing zones in the Uinta Formation. A single location (P-2 upper) contains an areally limited water-bearing zone near the Green River/Uinta Formation contact.

Geophysical logs of oil and gas wells in the area and holes drilled as part of the investigation (notably G-16A and P-4) indicate that the Douglas Creek Member of the Green River Formation contains several hundred meters of water-bearing material. The data also indicate the quality of this water in the vicinity of the tracts is better than that of the bird's nest aquifer or the Wasatch Formation. The water quality data of Austin and Skogerboe (1970), Price and Miller (1974), and Feltis (1968) support these findings.

Investigation of the alluvial channel materials on and adjacent to the tracts has been sufficient to describe the presence or absence of water and its temporal distribution. Southam Canyon, the principal area of interest (owing to potential processed-shale deposition) has been monitored with five alluvial wells. Only the downstream well near the confluence with the White River contains water, which is presumably residual from drilling and aquifer testing a few hundred meters upstream.

The proposed mining within the mahogany zone should have no effect upon the occurrence of ground water in the bird's nest aquifer or the Douglas Creek Member, since both are well shielded from one another and because no measurable amounts of water in the interval between were observed during drilling.

b. Aquifers

An objective of the ground water exploration program was to identify aquifers between the ground surface and to a depth of 137.2 m (450 ft) below the mining zone. This was accomplished by drilling four continuous core holes (P-1, P-2, P-3, and P-4) to that depth and carefully monitoring the rate of discharge and the specific conductance of the discharge. The four holes were geophysically logged and packer tested in zones indicated by the logs to be favorable to water production. The data from all four holes indicate little potential for water production in the Uinta Formation or to about 106.7 m (350 ft) below the mining zone, where the Douglas Creek Member of the Green River Formation is encountered.

Data from available literature, core samples, geophysical logs, and inspections of outcrops were sufficient to identify the location with depth, the thickness, and the lithologic and structural properties that characterize the bird's nest aquifer. The data were not sufficient to establish that there is no interconnection between the Douglas Creek Member and the bird's nest aquifer; however, interconnection is unlikely because of significant differences in water chemistry and the absence of water in many zones between the Douglas Creek Member and bird's nest aquifer.

The hydraulic characteristics of the bird's nest aquifer were determined at three locations widely different in terms of artesian head and water-table conditions. The test results and additional data were adequate to generally describe the aquifer characteristics across the tracts. All the data indicate that the aquifer is not interconnected with the P-2 upper or Douglas Creek Member in the area of the investigation.

The proposed mining program is not expected to create any interconnection between the bird's nest aquifer and Douglas Creek member nor is it expected to create vertical flow from either aquifer into the workings. However, because of the lack of conclusive proof of the separation of aquifers, it would be advantageous to design an intensified monitoring program in the event that large flows are encountered in the workings. Otherwise, the monitoring of ground water

levels and ground water quality should be conducted as set forth in the Detailed Development Plan (DDP) throughout the developmental stage.

c. Ground Water Recharge

At least two years of water-level data were collected from wells penetrating the artesian and water-table portions of the bird's nest aquifer. These data show very little fluctuation over the period of record, suggesting that the main body of the reservoir is full to capacity and that recharge equals discharge.

Recharge to the bird's nest aquifer is known to occur in the area of the south boundary of Tract U-b where the aquifer and the channel of Evacuation Creek are in hydraulic communication; however, water flowing into the aquifer at this location is offset by outflow back to the channel near surface water station S-2, which is estimated to be about 1.42 l/s (0.05 cfs). If the aquifer were drawn upon heavily as a water source, greater quantities of water could be induced to flow into the aquifer from Evacuation Creek and the White River. The volume of induced recharge has not been estimated because based upon its water quality, it is unlikely that the aquifer will be used as a water supply in the near future.

Mining is not expected to cause any mass redistribution of water levels and is therefore not expected to induce large amounts of recharge, either from the White River or Evacuation Creek--the two known points of recharge. Evidence of induced recharge would come from the water level monitoring program proposed in the DDP.

d. Ground Water Movement and Fluctuation

Sufficient subsurface data were collected, and surface-control points were monitored for a sufficient period of time for accurate assessment of the direction of ground water movement and the fluctuation of the water surface. Both seasonal and barometric-pressure fluctuations were observed and recorded. Hydraulic gradient and water quality differences indicated the direction of ground water movement. Hydraulic conductivities as measured from aquifer tests and the hydraulic gradient may be used to compute the rates of flow.

Providing that there are no subflows from the bird's nest aquifer into the workings, the only effect of development

upon the movement of ground water and water level fluctuations will be during the sinking of the mine shaft through the bird's nest aquifer. Inflow to the shaft will be stopped as soon as practicable by cementing and casing as stipulated in the DDP. Inflows to the shaft will be temporary, as will be the effect upon water levels. Specific monitoring should not be necessary for this aspect of development.

e. Ground Water Discharge

Discharge of bird's nest aquifer water from the tract area is known to occur at two locations: the Evacuation Creek channel and the canyon of the White River. Surface water station S-2 in Evacuation Creek is situated so that most of the flow passing the station is discharged from the aquifer. The station is not situated to monitor all the discharge, because the aquifer continues to discharge for some distance downstream of S-2.

Analysis of the flow records of stations S-1 and S-3 on the White River do not indicate any measurable flow differences attributable to discharge from the aquifer to the river, even though such discharge is known to occur between the two stations. The river cuts across the strike of the aquifer, and Evacuation Creek is continuously cutting along the strike, which exposes much more length of aquifer. It is reasonable to assume that discharge is greater in Evacuation Creek than in the river.

None of the proposed development activities are expected to affect ground water discharge. Any decrease in discharge would be monitored at surface gaging station S-2.

f. Ground Water Quality

A sufficient number of samples have been collected from the Douglas Creek Member, the bird's nest aquifer, P-2 upper, and the alluvium to characterize the quality of their contained water for various elements and compounds. Overall quality differences have been observed among and within the aquifers, but when taken together with other information (lithologic differences, flow direction, source of recharge, distance from recharge points, etc.), it is felt that the quality of water has been assessed with sufficient thoroughness to establish baseline conditions.

Because no large-scale effects on ground water movement within the bird's nest aquifer are expected to occur, mass redistribution of the bird's nest NE or SW water types are not

expected either. In any event, such a redistribution would have little effect on how these waters could be used, because both of the water types are unsuitable for most uses, and it is doubtful that redistribution and co-mingling would make the water quality any better or any worse.

The baseline program has clearly established that many of the water quality constituents measured are not in sufficient concentrations to warrant additional measuring. Future monitoring should include the major anions and cations, plus COD, NH_4 , NO_2 , NO_3 , TOC, and TIC. The customary field measurements of temperature, pH, and specific conductance should accompany sampling. These constituents would account for 98% of the constituents in the water as well as anything resulting from the proposed development.

g. Ground Water Use

The regional investigation disclosed that in the vicinity of the tracts, limited quantities of ground water are being used. The American Gilsonite Company uses water from the White River alluvium for commercial uses, and perhaps as many as five flowing wells producing from the Douglas Creek Member in Asphalt Wash are used by the BLM for stock water.

One or more constituents in all the ground water sources on and in the vicinity of the tracts exceed recommended limits. This is especially true of water from the bird's nest aquifer, which is high in TDS, sulfate, SAR, fluoride, bicarbonate, hardness, and boron.

The proposed development is not expected to affect the present use of ground water, because the water is generally unsuitable for most uses unless treated.

Glossary

GLOSSARY

Aquifer: a saturated bed, formation, or group of formations which yields water in sufficient quantity to be of consequence as a source of supply.

Alluvium: a general term for clay, silt, sand, gravel, or similar unconsolidated detrital material deposited during comparatively recent geologic time by a stream or other body of running water as a sorted or semi-sorted sediment in the bed of the stream or on its flood plain or delta, or as a cone or fan at the base of a mountain slope. Syn: alluvial, alluvial deposit.

Artesian head: the hydrostatic head or height of a vertical column of water, the weight of which, if of unit cross-section, is equal to the hydrostatic pressure at a point of an artesian aquifer or of the water in the aquifer.

Diurnal variation: variation throughout daylight hours.

Evapotranspiration: loss of water from a land area through transpiration of plants and evaporation from the soil. Also, the volume of water lost through evapotranspiration.

Formation: the basic or fundamental rock-stratigraphic unit in the local classification of rocks, consisting of a body of rock generally characterized by some degree of internal lithologic homogeneity or distinctive lithologic features such as chemical composition, structures, textures, or gross aspect of fossils, by a prevailing but not necessarily tabular shape, and by mappability at the earth's surface. Syn: geologic formation.

Geophysical log: a log obtained by lowering an instrument into a borehole or well and recording continuously on a meter at the surface some physical property of rock material being logged.

Incised: in geomorphology, said of a stream meander or notch that has downcut or entrenched into the surface during, and because of, relative uplift of the surface.

Member: a rock-stratigraphic unit of subordinate rank, comprising some specially developed part of a varied formation such as a lithologically unified subdivision distinguished from adjacent parts of the formation by color, hardness, composition, or similar features and not defined by specified shape or extent.

Potentiometric surface: an imaginary surface representing the static head of ground water and defined by the level to which water will rise in a well. Syn: piezometric surface, isopotential level, pressure surface.

Resistivity: a measure of varying resistance to an electric current of the sequence of rock units opposite the traveling electrode. It is used to determine the nature of the strata penetrated.

Specific conductance: the electrical conductance, measured in μmhos , is the inverse of electrical resistance.

Spontaneous-potential: potential at different depths of a borehole used to indicate porosity and permeability of the rocks penetrated.

Transmissivity: in an aquifer, the rate at which water of the prevailing viscosity is transmitted through a unit width under a unit hydraulic gradient. Though spoken of as a property of the aquifer, it embodies also the saturated thickness and properties of the contained liquid.

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III AIR RESOURCES



III. AIR RESOURCES

The purpose of the air resources study was to evaluate existing air quality and meteorological conditions on the tracts and within a 1.6-km (1-mi) perimeter around the tracts against which conditions during plant operation could be compared.

A network of 12 fixed meteorology stations was installed for continuous monitoring of wind speed and direction and temperature at various levels. Eight of the twelve stations were also used to measure hydrogen sulfide, sulfur dioxide, and suspended particulates. Three air quality/meteorology stations were comprehensive stations strategically located on the tracts for the collection of the following additional parameters: relative humidity, dew point, lateral and vertical turbulence, upper air speed and direction, barometric pressure, net radiation flux, lapse rate, hydrocarbons, nitrogen dioxide, carbon monoxide, ozone, coefficient of haze, trace metals, and visual range.

The two years of air resources monitoring for the environmental baseline monitoring program were completed on January 15, 1977. During the second year, changes to the original scope of work were implemented with the approval of the Area Oil Shale Supervisor. Some of these changes were incorporated at the end of January 1976, and the rest, in May 1976. The scope of each element of the revised program and its rationale and the results of the air resources program are discussed below.

A. METEOROLOGY

The weather on the tracts is essentially determined by their latitude, elevation above sea level, and location with respect to the average storm tracks over the intermountain region. A large portion of the moisture from Pacific storms falls across the Sierra Nevada or Cascade mountain ranges before reaching Utah, and therefore the prevailing westerly air currents reaching the tracts are comparatively dry. Clear skies prevail most of the year, with strong insolation during the day and rapid nocturnal cooling, resulting in fairly wide daily ranges in temperatures. On clear nights the colder air usually accumulates by drainage from higher terrain down to the White River channel and low-lying areas.

The synoptic meteorological patterns observed during the two years of monitoring show that high-pressure areas were most prevalent in the winter and least prevalent during summer. These high-pressure regions tended to settle over the intermountain area and would often persist for a week or more. Wind speeds during such conditions were usually light to moderate. An example of this type of synoptic pattern is shown on Figure III-1.

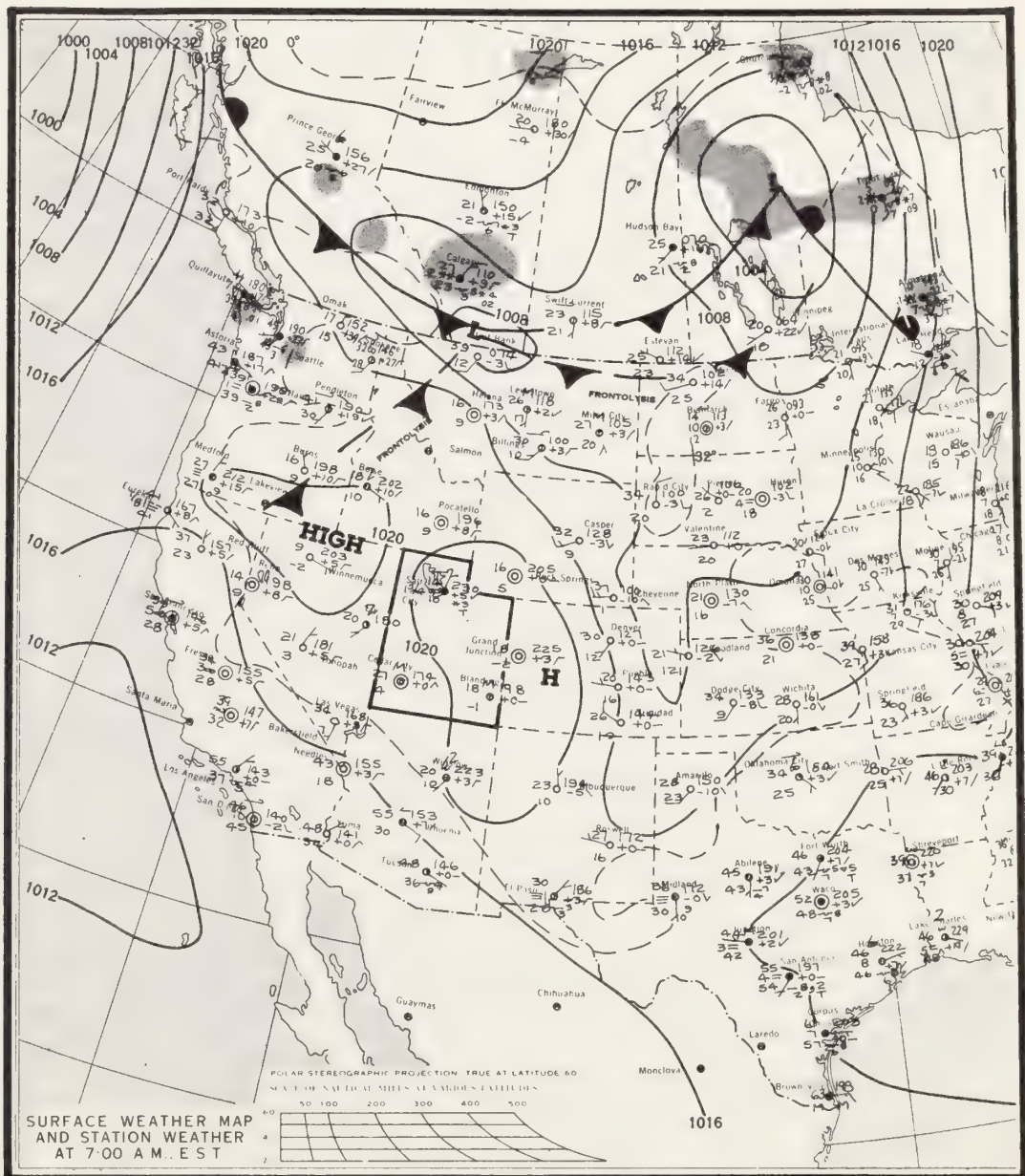


FIGURE III-1. SYNOPTIC WEATHER PATTERN ASSOCIATED WITH HIGH PRESSURE AND WEAK SURFACE FLOW OVER THE TRACTS.

Occasional storms with high winds were usually associated with the movement of low-pressure disturbances through the area, as shown on Figure III-2. The intensity and frequency of these frontal passages (both with and without moisture) were highest during February through April. The high winds associated with this synoptic situation are of comparatively short duration compared with the light air flow associated with the high-pressure regimes.

1. SURFACE METEOROLOGY

a. Methodology

Continuous meteorological measurements were made from the inception of the program until May 1, 1976, at 12 air monitoring stations in and around the tracts. After May 1, 1976, stations A1, A5, A8, A9 and A12 were shut down, and measurements at a new station, A13, were begun. The locations of these stations and the meteorological parameters measured are shown on Figure III-3.

Most of these changes were made in consideration of the oil shale plant site location, which is proposed for Section 22 of Tract U-a. Stations A1, A8, and A12 were remote from the proposed plant site, and one year of data collection provided sufficient meteorological information to characterize baseline conditions there. The data from Station A9 duplicated that collected at other sites, and Station A5 was monitoring an area that would be submerged if the White River were dammed, as proposed. It was essential, however, that drainage flows in the general vicinity of the proposed plant site be monitored, and thus Station A13 was established. The types of instruments used and their accuracy and required calibration intervals are discussed in the First Year Environmental Baseline Report (FYEBR).

b. Summary of Results

The surface airflow pattern on the tracts is complicated by the effects of the rugged terrain in the area. Generally, drainage conditions dominate in the early morning hours, with airflow toward low terrain and down the White River. In the afternoon, the winds are more organized and are usually out of the west or southwest. This confirms the findings during the first year. Figures III-4 and III-5 show typical morning and afternoon airflow patterns: the solid arrows indicate wind vectors at monitoring sites, and the longer lines indicate estimated flow

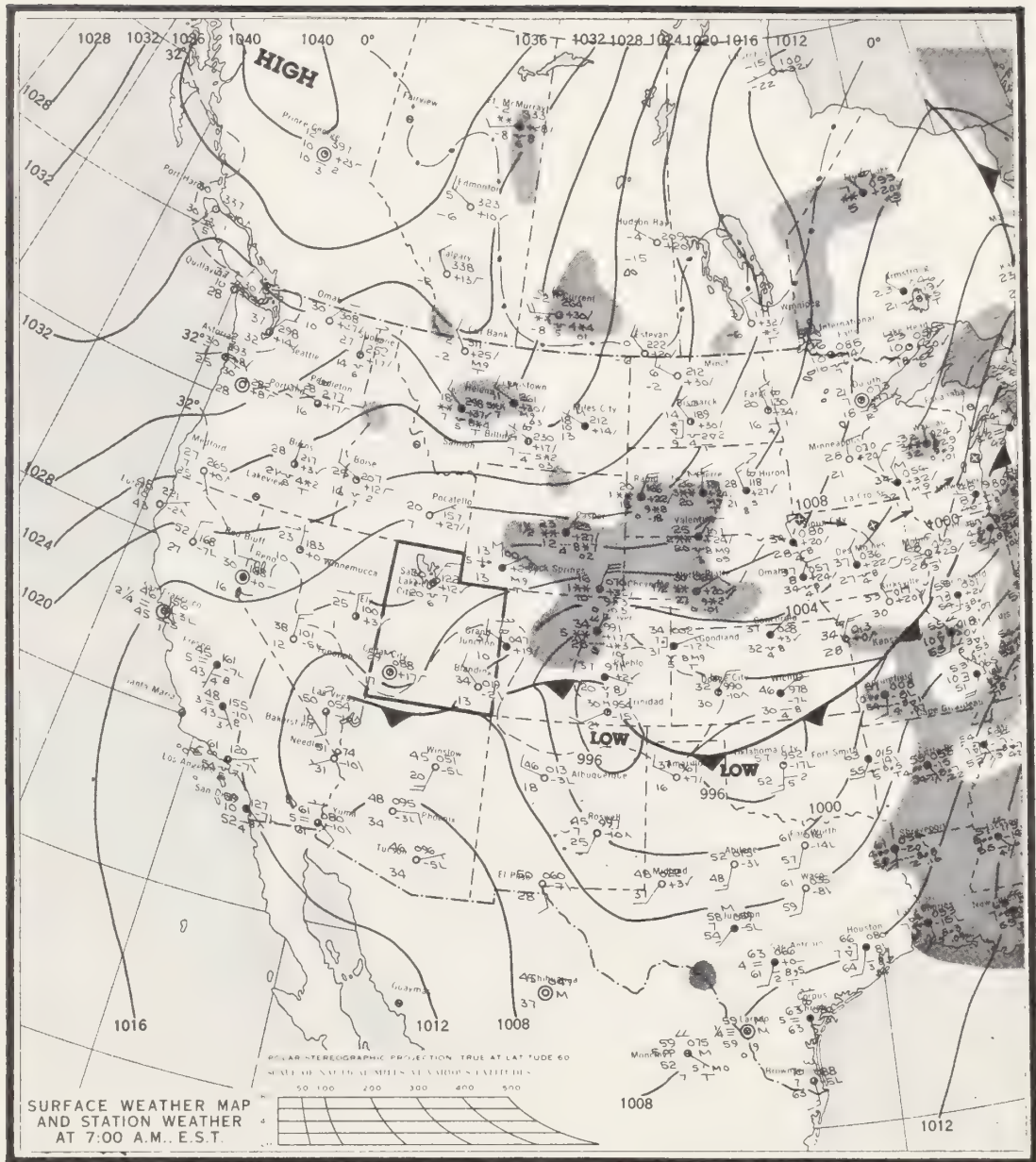


FIGURE III-2. SYNOPTIC PATTERN ASSOCIATED WITH FRONTAL
MOVEMENT AND STRONG SURFACE FLOW OVER THE
TRACTS.

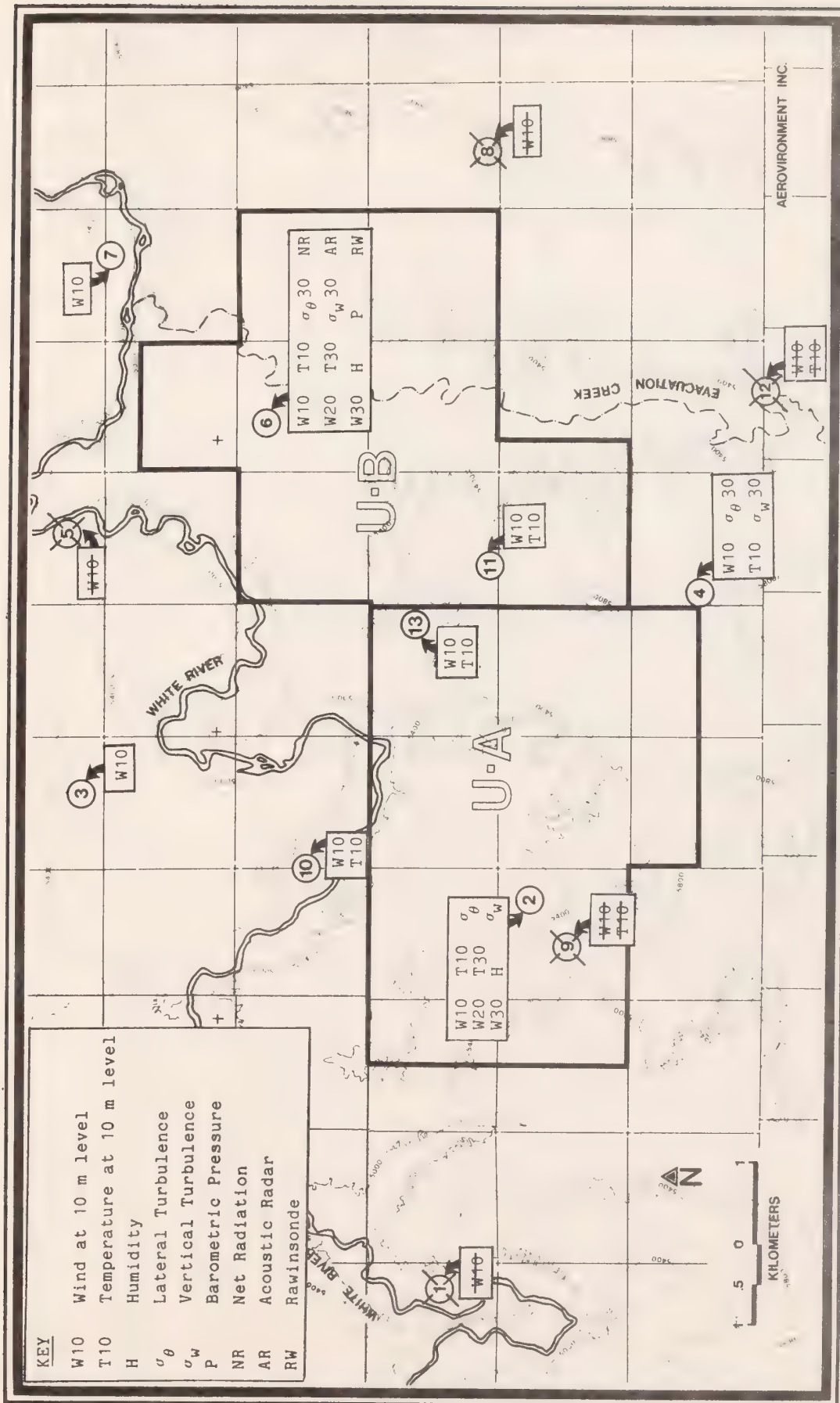
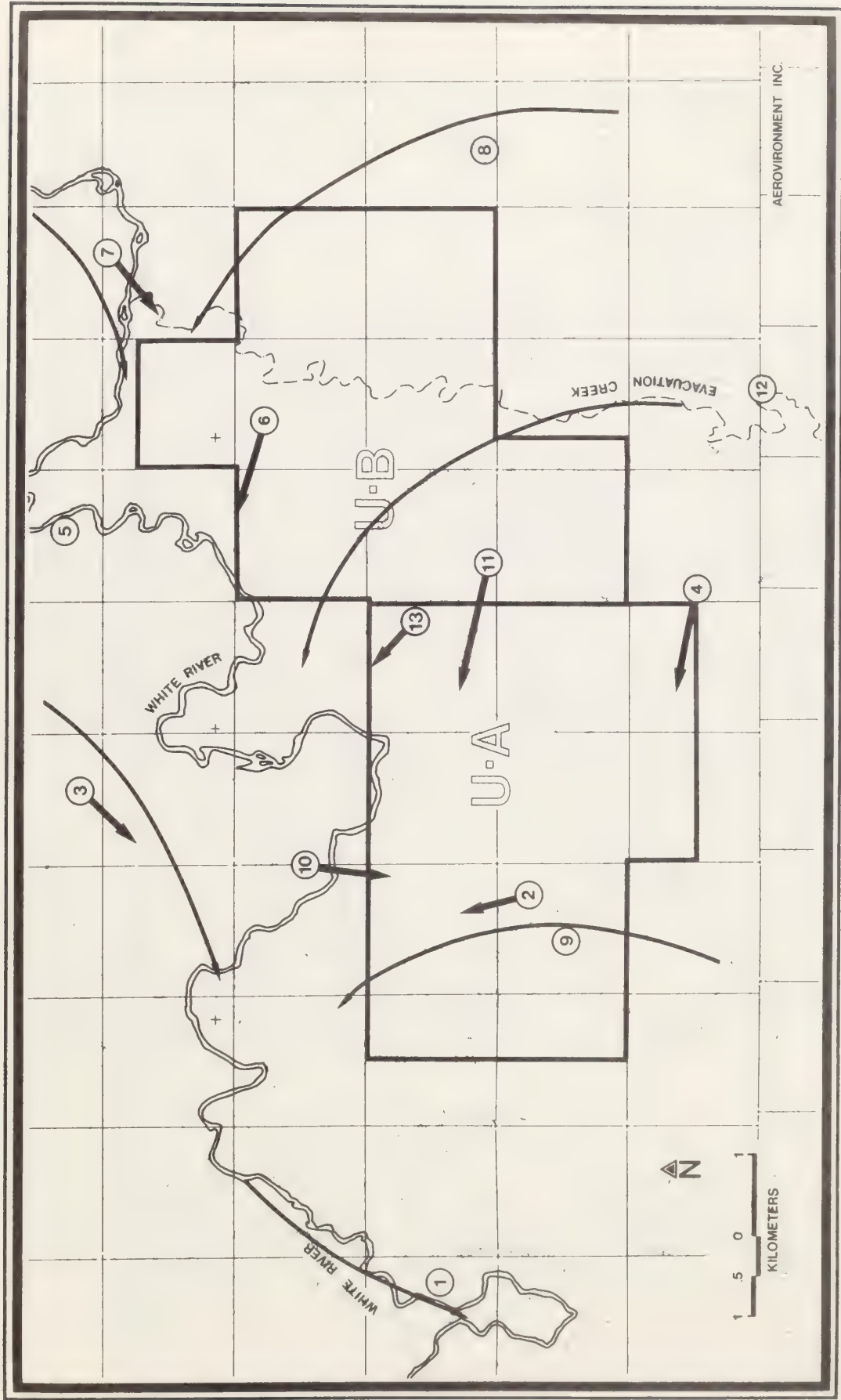
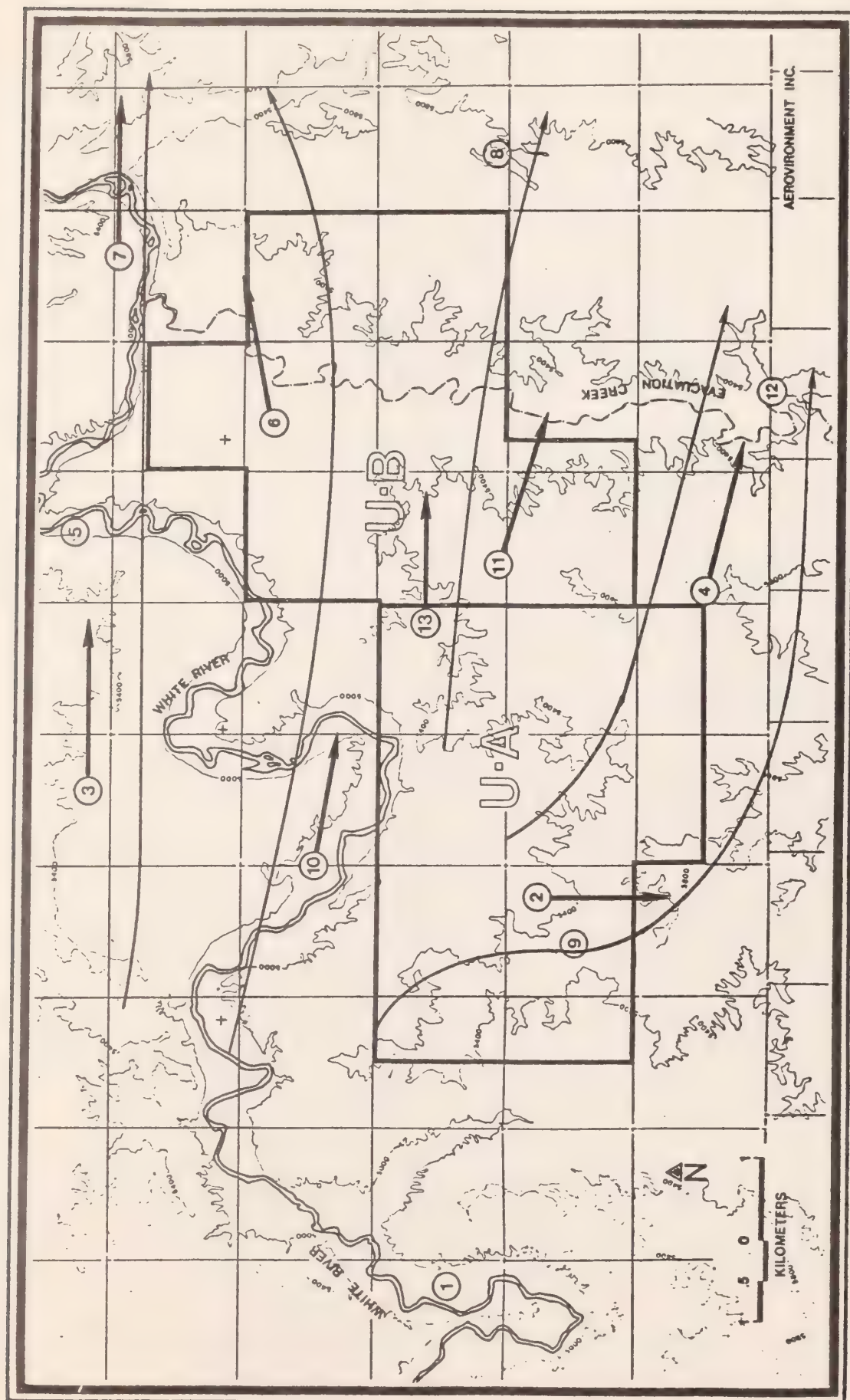


FIGURE III-3. LOCATION OF METEOROLOGICAL MEASUREMENT STATIONS ON TRACTS U-a AND U-b. Meteorological measurements were terminated in May 1976, at the stations which are crossed out, at which time Station 13 was activated.



2 m/s
 ↑ Wind Vector
 → Streamline

FIGURE III-4.
 TYPICAL AIRFLOW PATTERN ON TRACTS U-a AND U-b IN THE MORNING
 IN OCTOBER 1976.



2 m/s
 Wind Vector
 Streamline

FIGURE III-5. TYPICAL AIRFLOW PATTERN ON TRACTS U-a AND U-b IN THE AFTERNOON IN OCTOBER 1976.

streamlines. Streamline plots depicting airflow on the tracts for different seasons of the year are discussed in the FYEBR.

Two years of wind data have indicated that the spatial variations in the wind speeds on the tracts are caused by the complicated terrain features in the area. Generally, wind speeds over the ridges and widely exposed terrain are higher than those in protected valleys. Exceptionally high winds on the tracts are associated with passing fronts or low-pressure disturbances. Under such conditions, speeds of 10 m/s (22 mph) and above are not uncommon. High winds occur most frequently in spring. During winter there are often extended periods of light winds, generally 1-2 m/s (2-4 mph), with a high-pressure cell stagnating over the state of Utah.

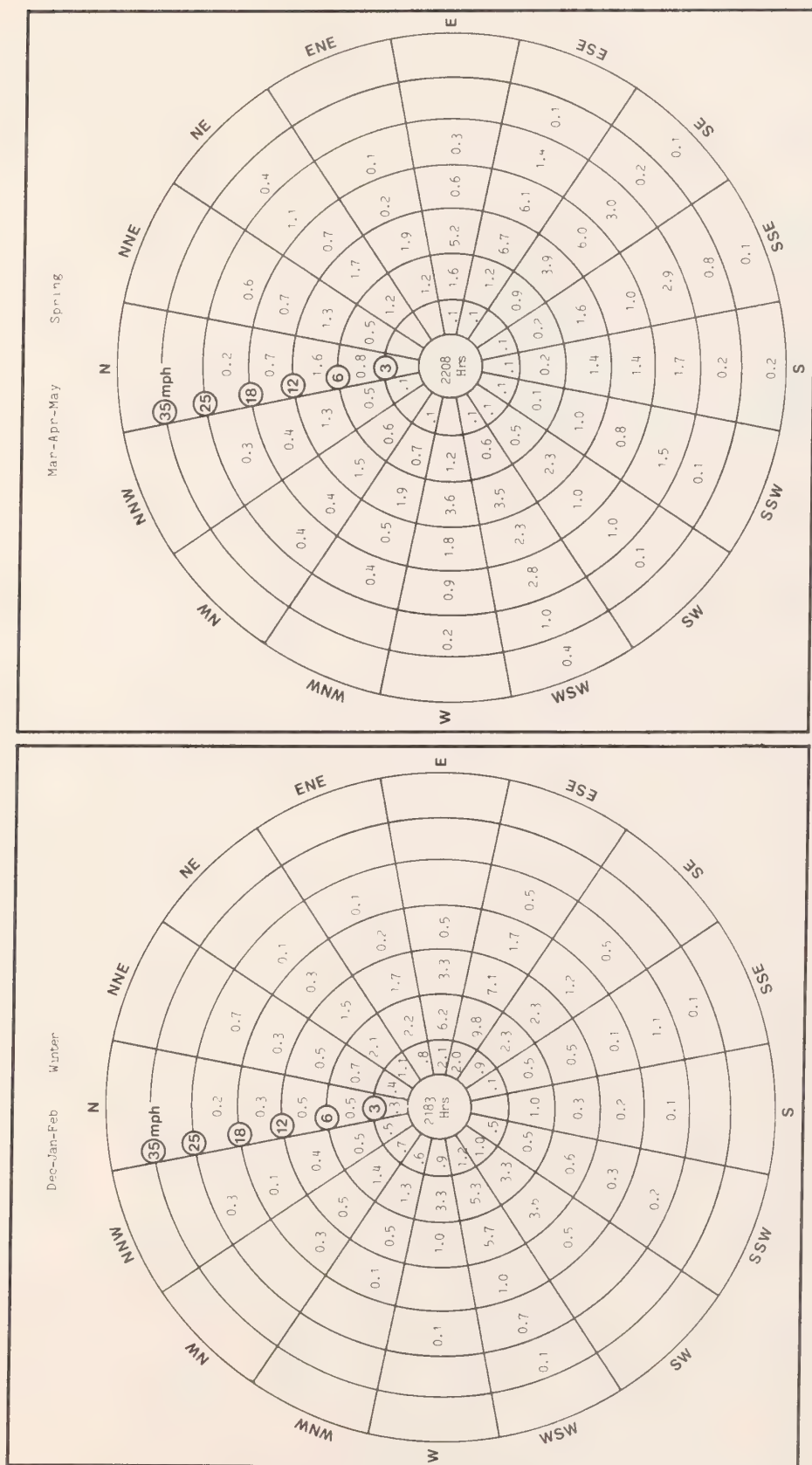
Figure III-6 shows relative frequency distributions of wind speed and direction at Station A6 for the four seasons of 1976. High winds of more than 8 m/s (18 mph) were most prevalent in spring, with a 22% frequency of occurrence, primarily from the WSW direction. Winds of that strength were least common in fall, when the frequency of occurrence dropped to 1%. Similar results were reported for 1975, with high winds usually from the southwest and occurring most often in the spring. During winter of the first year, high winds occurred with only a 2% frequency of occurrence and came usually from the west. High winds were equally frequent (9%) in summer and fall of 1975 and came usually from the southwest.

Low winds (below 1.3 m/s, or 3 mph) were more frequent in winter (13%), with the majority coming from the east, and least frequent in spring (<1%). During the first year, low winds were also most prevalent in winter, with a 15% frequency of occurrence; however, they were primarily from the west. In 1975, low winds were least common in the fall (4% frequency of occurrence) and were usually from the southeast. The spring and summer seasons of 1975 indicated low winds with equal frequency of occurrence (8%) from the southeast.

Excluding days with unusual synoptic weather patterns, the winds were lower at night and higher in the afternoon. The typical diurnal variation of mean wind speed and its standard deviation is shown by data collected for July 1976 at Station A6, on Figure III-7. Similar diurnal variation was also exhibited during 1975.

Temperature readings varied from station to station, but only by a few degrees. Temperatures were usually lower in protected valleys and river beds and higher in well-exposed areas. The lowest reading observed during the second year was -29°C (-20°F).*

* This is the lowest value that could be recorded by the instrumentation in use.



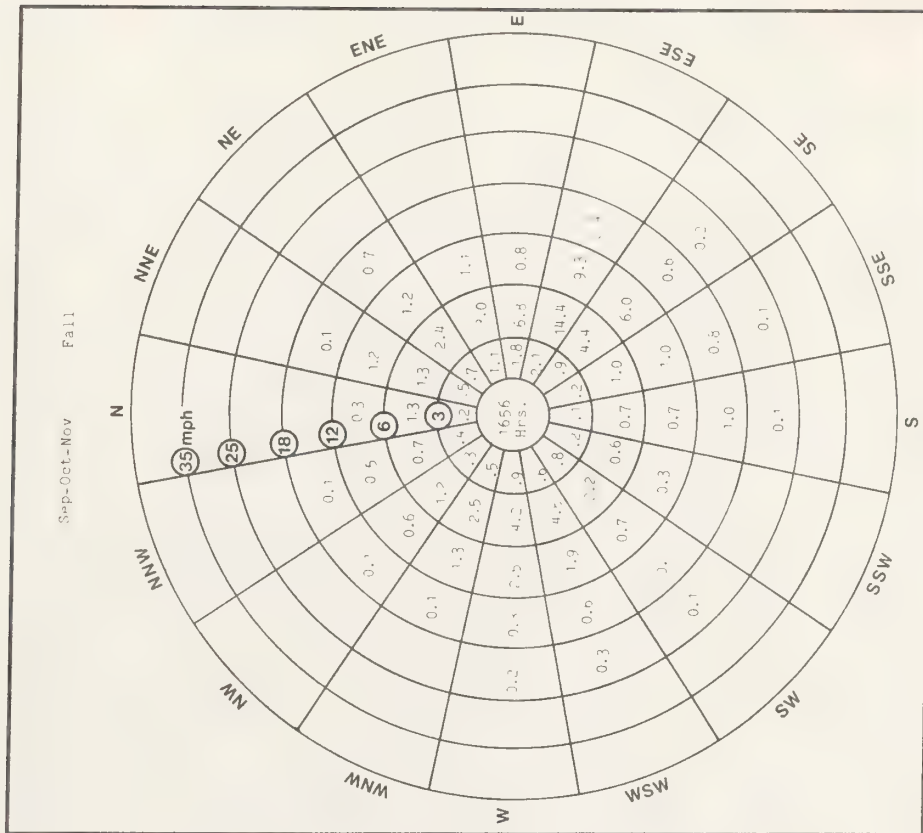
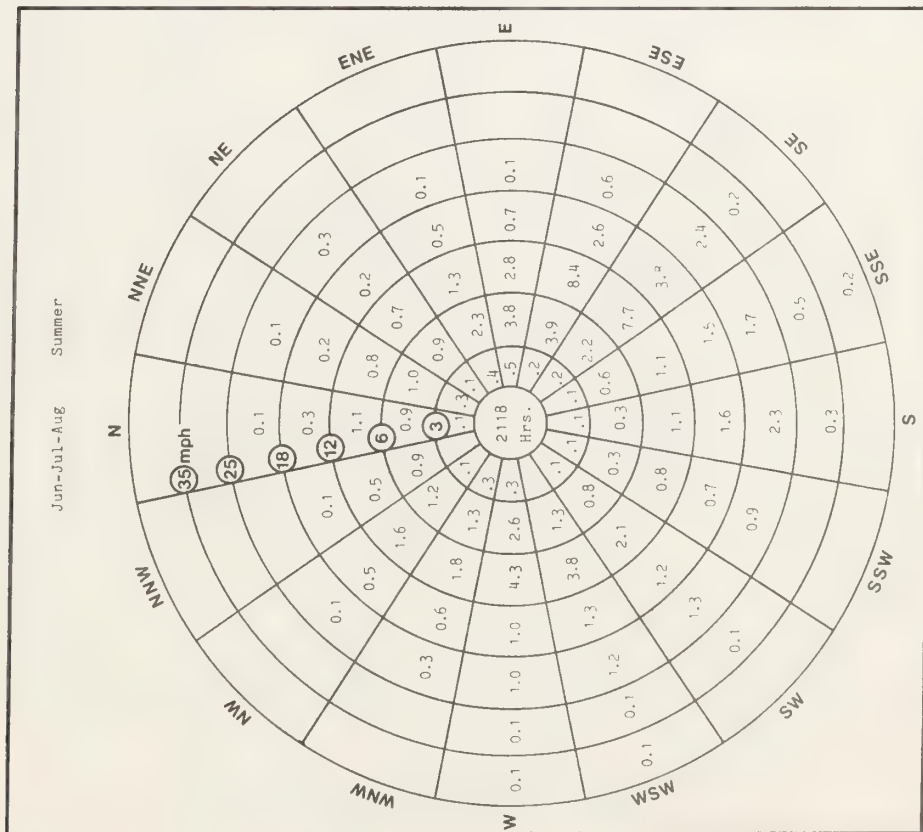


FIGURE III-6. (Continued)

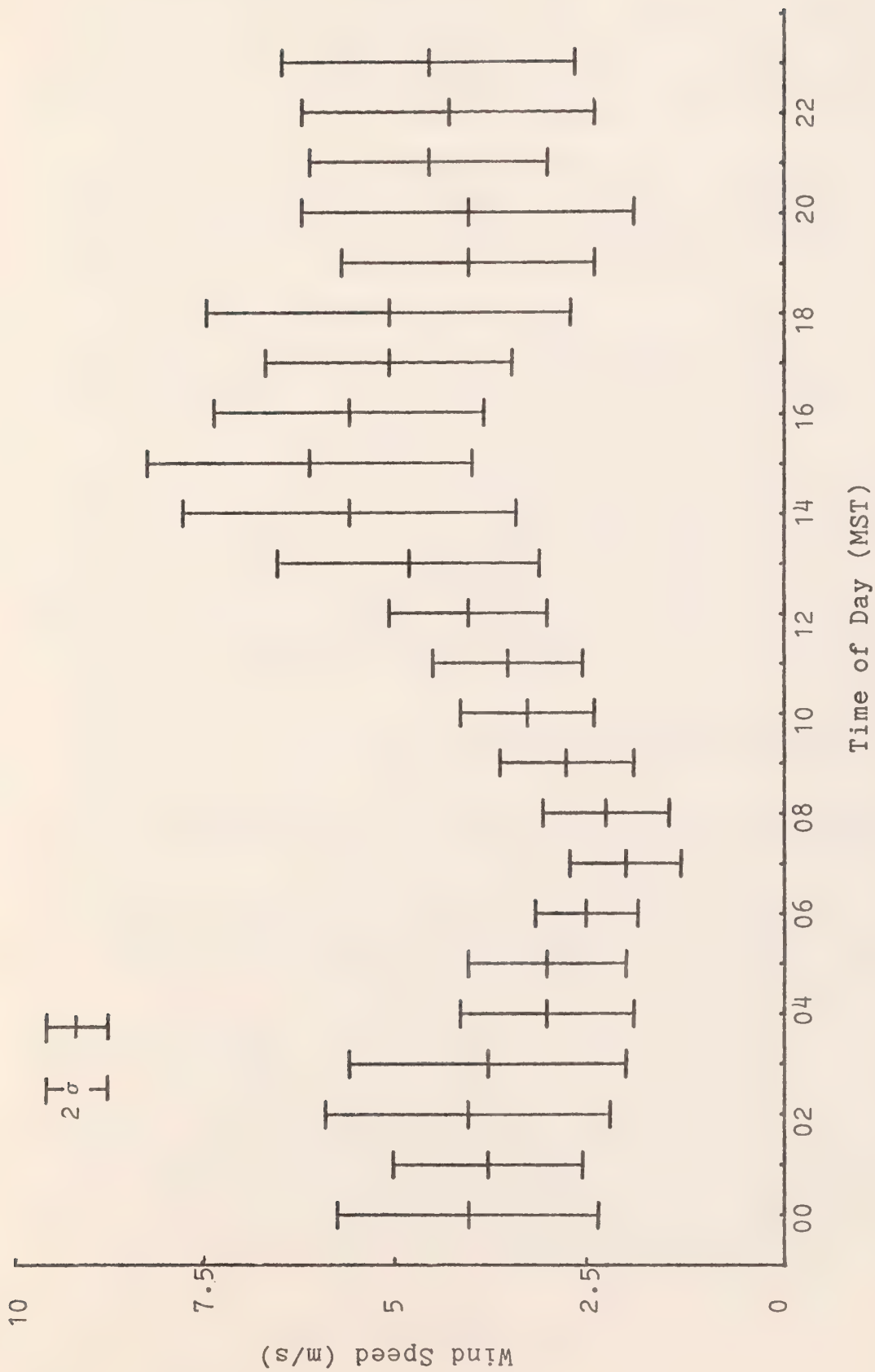


FIGURE III-7. DIURNAL VARIATION OF MEAN WIND SPEEDS AND THEIR STANDARD DEVIATION AT STATION A6 IN JULY 1976, A TYPICAL SUMMER MONTH. (1 m/s = 2.24 mph)

recorded in January 1976 at Station A10, and the highest reading was 41°C (106°F), recorded in July 1976 at Station A13. The monthly mean, maximum, and minimum temperatures at Station A6 for 1976 are listed on Figure III-8. The data show that during the second year January was the coldest month and July the warmest. This was a change from the previous year, in which February was the coldest month.

On a typical day, the temperature was lowest at 0500-0600 in the morning and highest at 1400-1500 in the afternoon. The diurnal variation in temperature at Station A6 in January and July 1976, the coldest and hottest months of the year, respectively, is shown on Figure III-9.

For purposes of comparison, Figure III-10 gives the diurnal variation for February and July 1975, the two months of temperature extremes on the tracts. During 1975 temperatures ranged from an average low of -9°C (16°F) on February mornings to an average high of 30°C (86°F) on July afternoons.

The relative humidity on the tracts was lowest in summer and highest in winter. The diurnal variation of relative humidity was usually approximately the reciprocal of that of temperature, indicating that the amount of water vapor in the air remains constant during the day. Figure III-11 shows a typical diurnal trend. The lowest reading (8%) occurred around 1400-1500, and the highest reading (75%) occurred around 0400-0500.

c. Interpretation and Conclusions

Surface meteorological data collected during the second year further support the findings derived from first-year data. These findings are as follows:

There is considerable spatial variation in wind and to a lesser degree, in temperature, on the tracts. This variability is attributable to the complex terrain features in the area.

At night, wind is of the drainage type. In the afternoon, wind is usually out of the west.

Exceptionally high winds are associated with passing fronts and low-pressure disturbances, which occur most frequently in spring. Low winds are most prevalent in winter, when the weather on the tracts is dominated by persistent high-pressure cells.

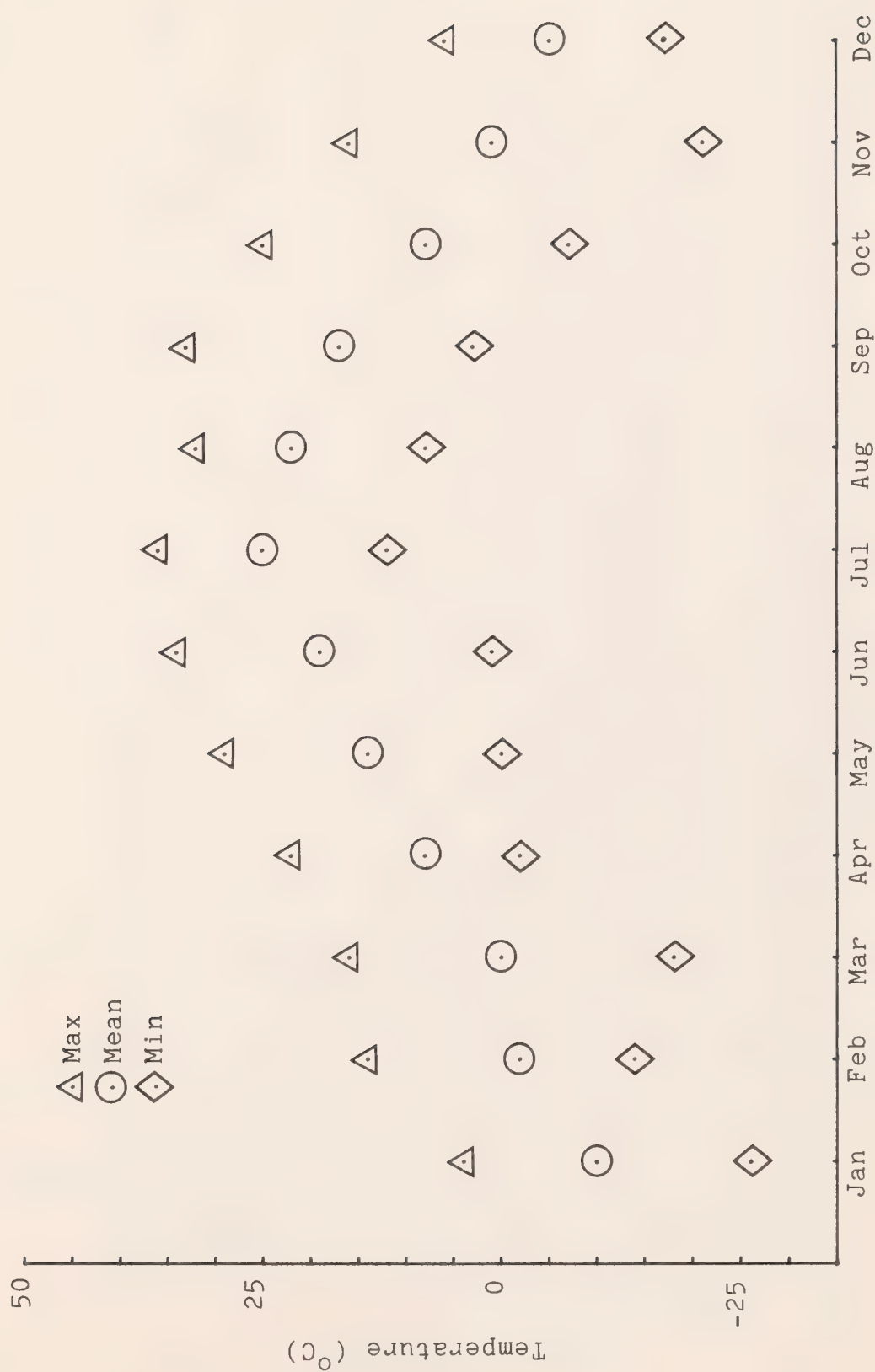


FIGURE III-8. THE MONTHLY MEAN, MAXIMUM AND MINIMUM TEMPERATURE READINGS AT STATION A6 IN 1976.

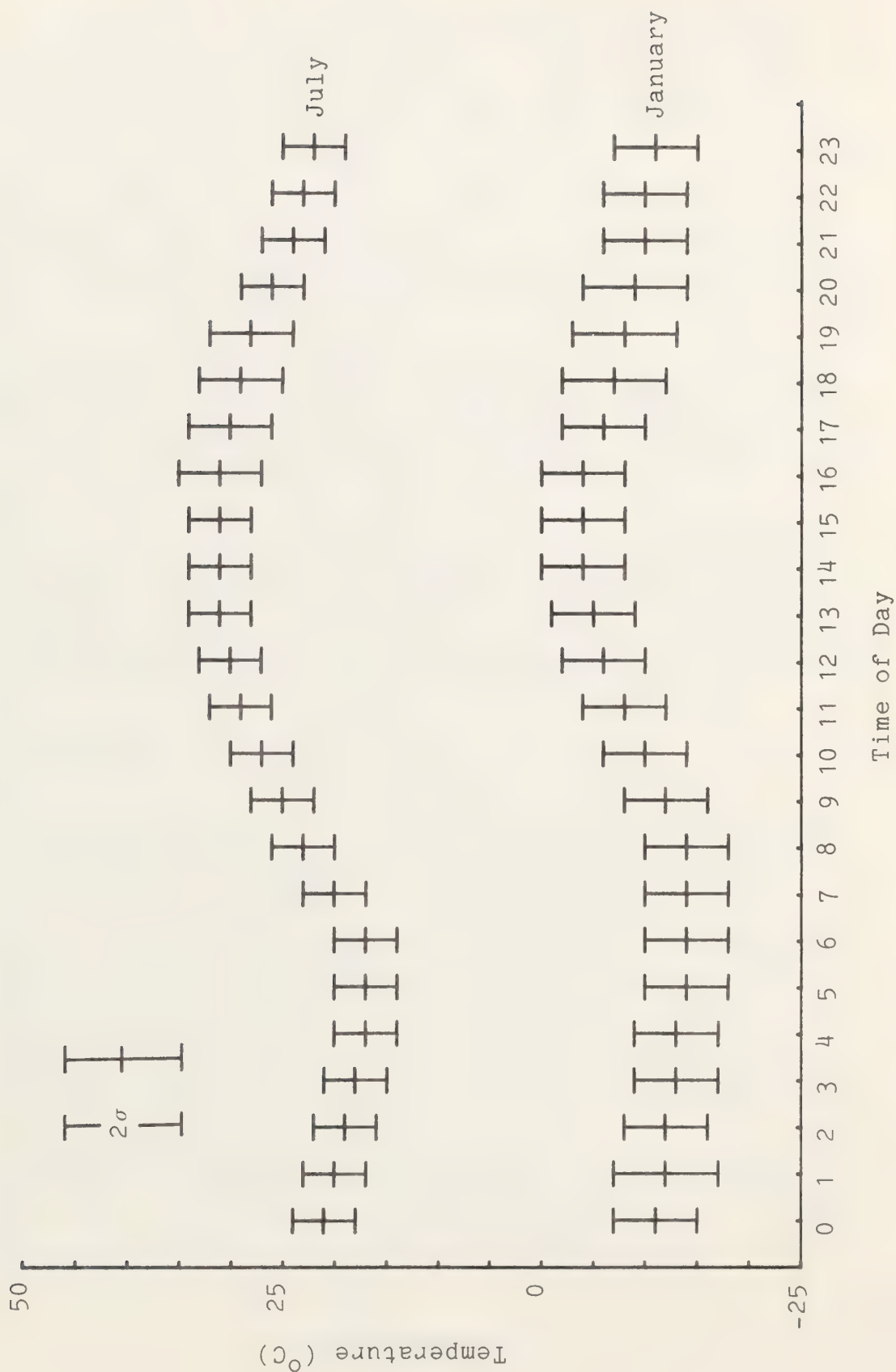


FIGURE III-9. DIURNAL VARIATION OF TEMPERATURE IN JANUARY AND JULY 1976
AT STATION A6.

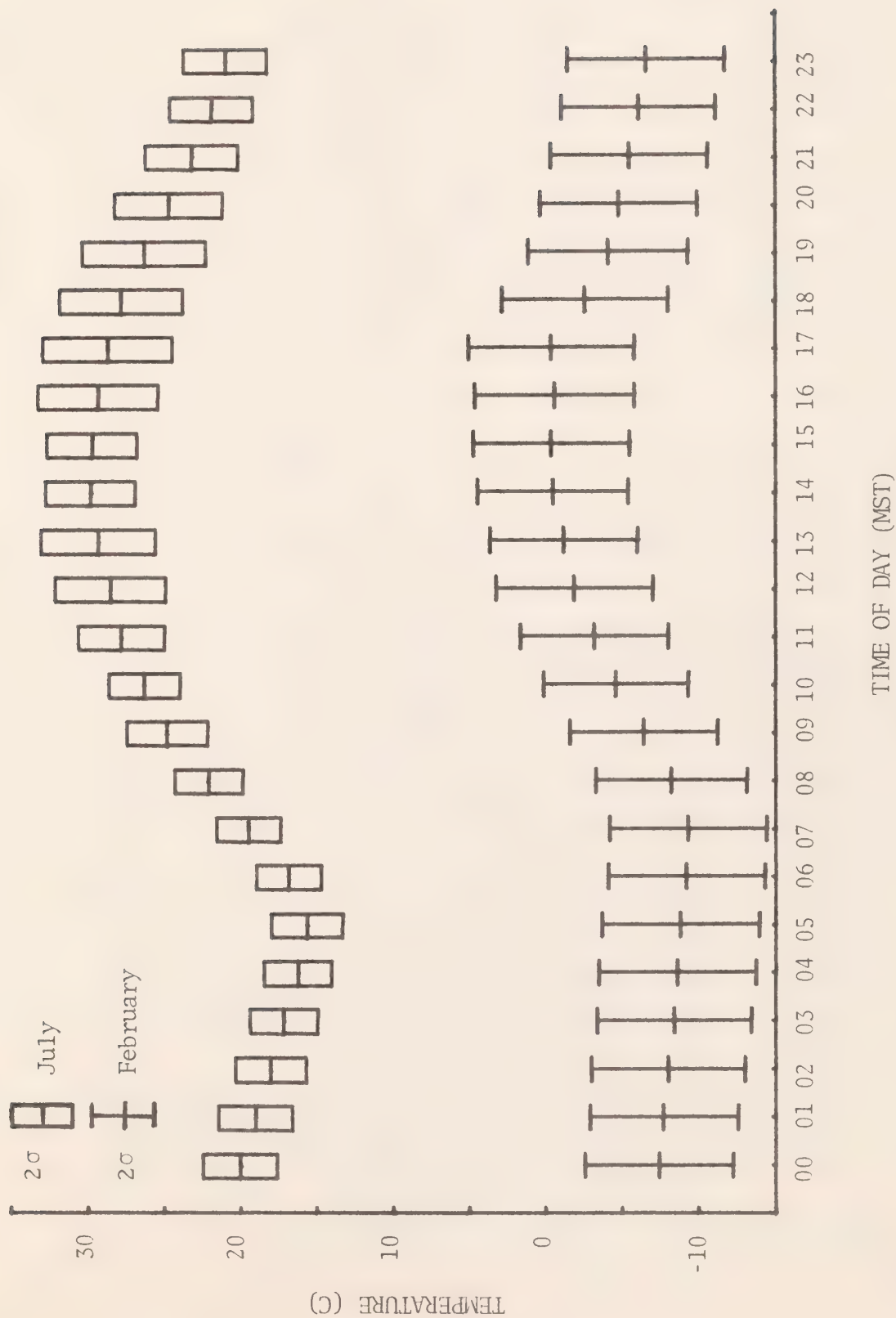


FIGURE III-10. DIURNAL VARIATION OF TEMPERATURE IN FEBRUARY AND JULY 1975 AT STATION A6.

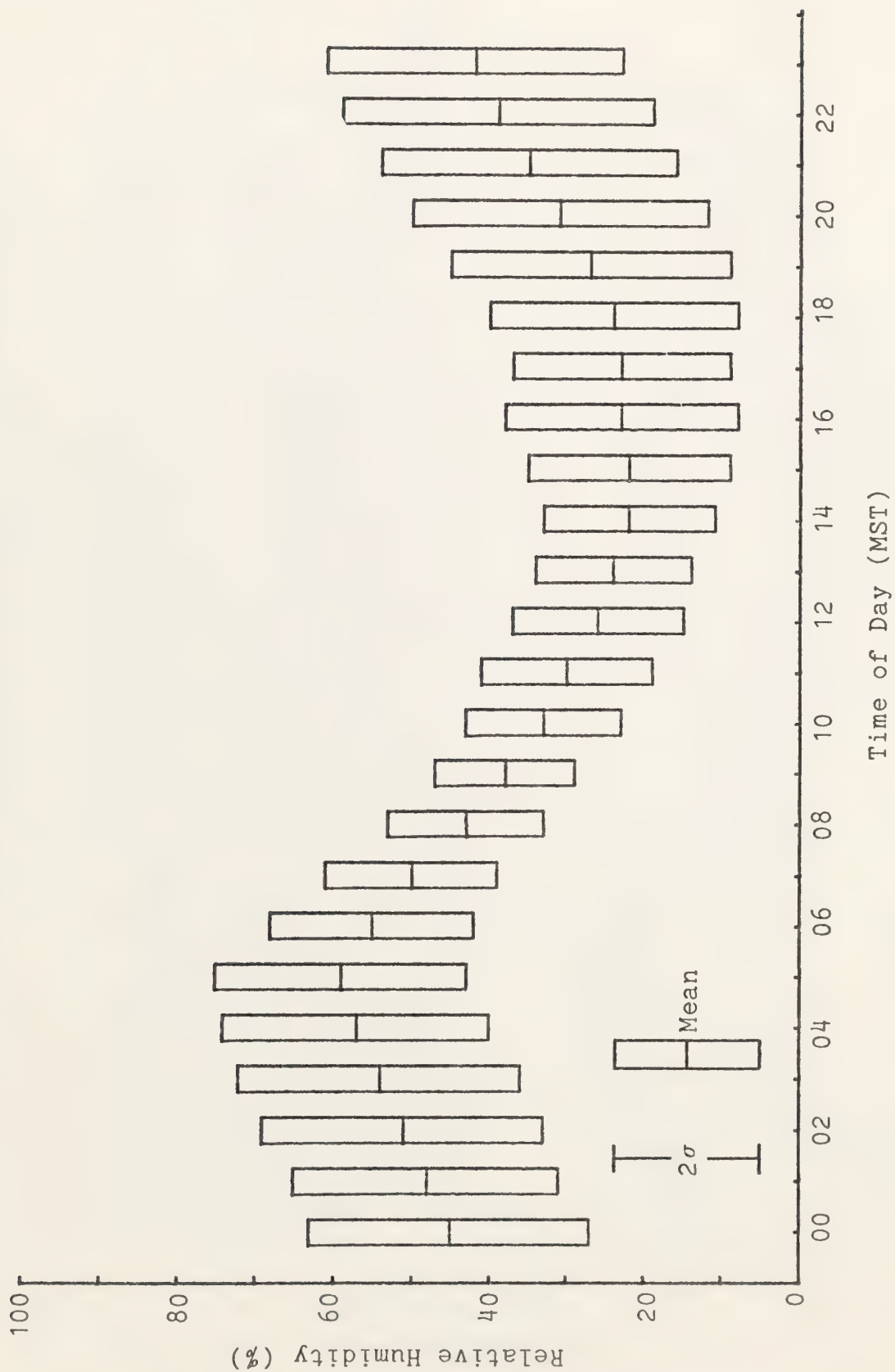


FIGURE III-11. DIURNAL VARIATION OF MEAN RELATIVE HUMIDITY READINGS AND THEIR STANDARD DEVIATIONS AT STATION A6 DURING JULY, 1976.

On a typical day, diurnal wind speed, temperature, and relative humidity vary consistently. Winds and temperature are lowest in the early morning hours and highest in the afternoon. Relative humidity demonstrates the opposite trend -- highest in the early morning hours and lowest in the afternoon.

There were no significant differences between the First and Second years.

It was pointed out in the FYEBR that surface-based or elevated inversions are common in winter. This, combined with the preceding observations, indicates that diffusion of pollutants will be of greatest concern in winter, especially during the early morning. Concentrations of particulates and photo-chemically generated pollutants depend on other atmospheric phenomena. These pollutants and diffusivity are discussed in the following sections.

2. UPPER AIR METEOROLOGY

At the end of the first year of baseline monitoring, upper air measurements by rawinsonde and acoustic sounding were terminated. Data for that year are discussed in the FYEBR.

In summary, during the entire study period, a surface-based inversion attributable to nocturnal cooling of the earth's surface usually occurred in the morning and usually disappeared in the afternoon. The average thickness of the morning surface-based inversion increased from about 243 m in winter to 253 m in spring and from 362 m in summer and to 409 m in fall. The strength of the inversion in winter, spring, and fall was about 2°C/100 m. The strength of the inversion in summer was much weaker, averaging 1°C/100 m.

Relative humidity in the lower kilometer above ground level (AGL) was about 70% in the morning and about 50% in the afternoon from winter to spring. In summer the relative humidity in the lower kilometer decreased to about 50% in the morning and to about 30% in the afternoon. In fall it was about 40% in the morning and about 35% in the afternoon.

Winds in the first kilometer above the ground were variable from day to day, whereas above the first kilometer the winds were usually from the west with an average speed of about 8 m/s (18 mph) during winter and spring and about 4 m/s (9 mph) in summer and fall.

B. DIFFUSIVITY

1. METHODOLOGY

The dispersion or dilution of windborne effluents in the atmospheric boundary layer are very dependent on the turbulence intensity, or diffusivity, of the atmosphere. This diffusivity on the tracts can be characterized by the root-mean-square eddy velocities, both vertical (σ_w) and crosswind (σ_v) components, at stations A2, A4, and A6. Other measurements made by rawinsonde and acoustic radar during the first year to further define the diffusive character of the atmosphere have been discussed in previous reports, including the FYEBR.

2. SUMMARY OF RESULTS

The dispersion of a plume is often described mathematically by the following diffusion equation:

$$\frac{X}{Q} = \frac{1}{\pi \sigma_y \sigma_z U} \exp - \frac{1}{2} \left(\frac{H}{\sigma_z} \right)^2$$

where X is the surface concentration; Q is the source emission rate; σ_y , σ_z are horizontal and vertical dispersion coefficients, respectively; U is the mean wind speed; and H is the effective stack height. MacCready et al. (1974) show that at downwind distances in excess of the order of a kilometer, $\sigma_y^2 = \sigma_y^2 t$ and $\sigma_z^2 = \sigma_w^2 t$ where σ_v and σ_w are the root mean-square turbulence fluctuations in the lateral wind speed v and the vertical wind speed w and t is the time of plume travel. Using these relations for $H=0$, and noting that the location of a receptor is given by $x=Ut$, the formula can be as follows:

$$\frac{X}{Q} = \frac{1}{(\sigma_v \sigma_w)^{1/2} x}$$

This relationship, with H taken as zero, is valid along the centerline of a plume released aloft or at the surface for emissions released also at the surface (although ground effect makes the constant of proportionality twice as great in the latter case as in the former). For other cases the decay in X/Q with x is even greater because of the growth of σ_z in the exponential term of the full equation.

For receptors off the plume centerline, an exponential term, which includes concentration decay with lateral distance, y ,

from the centerline

$$\exp - \frac{k y^2 U}{\sigma_v x}$$

must be included in the analysis. Its impact will always be such as to decrease the concentrations expected.

Using this approach, a quantitative characterization of diffusivity on the tracts is possible using the measurements of $\sigma_\theta = \sigma_v / U$ and of σ_w made continuously at stations A2 and A6. Table III-1 gives the frequency distributions of the quantity $(\sigma_v \sigma_w)^{1/2}$, which is inversely proportional to X/Q , for the four seasons of 1976 at stations A2 and A6.

The data on Table III-1 demonstrate the following diffusivity characteristics:

The diffusivity (in terms of $\sigma_v \sigma_w$) is typically between 0.2 to 0.4 m/s.

The frequency of occurrence of high diffusivity (>1.0 m/s) is greatest in spring at Station A2 and in summer at Station A6.

The frequency of occurrence of low diffusivity (<0.2 m/s) is greatest in winter at both Stations A2 and A6.

Low diffusivity (<0.2 m/s) occurs more frequently at Station A2 than at Station A6, as a consequence of the more sheltered location of Station A2 in Southam Canyon.

In contrast to the general situation, the highest diffusivity ($\sigma_v \sigma_w \geq 1.2$ m/s) was also observed at Station A2, which is a consequence of the turbulence generated by wind over the more complex topography in the region of Station A2 than near Station A6.

Not shown in the table is the diurnal variation in the quantity $(\sigma_v \sigma_w)^{1/2}$. Throughout the baseline program, low values were generally observed at night and high values in the afternoon. Noting that this is also true for wind speed, it is probably that the dispersion of pollutants on the tracts is relatively good during the day and is more limited at night.

Although the quantity $(\sigma_v \sigma_w)^{1/2}$ is useful in determining dispersion on the tracts, it is more conventional to describe diffusivity by categorizing atmospheric conditions into stability classes. Using $\theta\sigma$ data at A2, A4, and A6, the frequency distribution of different stability classes for 1976 is computed and shown on Table III-2. The typing scheme, which follows that in Atomic Energy Safety Guide 23 (AEC 1972), is shown on Table III-3. The use of $\theta\sigma$ instead of ΔT to define stability

TABLE III-1. RELATIVE FREQUENCY DISTRIBUTION (%) OF $\sigma_v \sigma_w$ AT STATIONS A2 AND A6 IN 1976.

$\sqrt{\sigma_v \sigma_w}$ Qtr.	0.0	0.2	0.4	0.6	0.8	1.0	1.2	1.4	> 1.4	Total # of Obs.
Station A2										
Spring	2	36	19	18	12	8	4	1	0	2112
Summer	10	29	22	19	11	8	1	0	0	1702
Fall	23	52	18	5	1	1	0	0	0	974
Winter	30	50	11	4	4	1	0	0	0	1766
Station A6										
Spring	4	41	24	15	11	5	0	0	0	1994
Summer	0	34	27	20	11	7	1	0	0	2044
Fall	1	54	24	14	5	2	0	0	0	1619
Winter	5	69	22	3	1	0	0	0	0	2094

* Each interval of $\sqrt{\sigma_v \sigma_w}$ spans 0.20 m/s and commences with the value shown.

TABLE III-2. RELATIVE FREQUENCY DISTRIBUTION (%) OF STABILITY CLASSES AT STATIONS A2, A4 AND A6 IN 1976. Table III-3 defines the classes A-G.

Station	Season	Stability Classes							Total # of Obs.
		A	B	C	D	E	F	G	
A2	Winter	0	.1	3.5	45.5	50.5	.4	0	2184
	Spring	0	0	4.6	54.0	40.6	.8	0	2208
	Summer	0	0	2.1	53.0	43.6	1.3	0	2176
	Fall	0	.1	7.8	54.6	37.2	.3	0	2184
A4	Winter	0	.4	7.1	56.3	33.3	.7	2.2	2231
	Spring	.3	2.9	15.2	53.6	27.8	.2	0	2207
	Summer	1.5	8.2	27.6	48.9	13.5	.3	0	2208
	Fall	.2	2.9	20.6	47.6	28.6	.1	0	2168
A6	Winter	.7	.8	6.2	27.2	46.8	12.7	5.6	2204
	Spring	.3	.5	5.4	29.3	58.4	6.1	0	2208
	Summer	0	0	3.1	36.5	54.6	5.8	0	2117
	Fall	0	.4	6.2	27.2	46.4	19.7	.1	2182

TABLE III-3. CLASSIFICATION OF ATMOSPHERIC STABILITY.

<u>Stability Classification</u>	<u>Pasquill Categories</u>	<u>σ_θ *</u>
Extremely unstable	A	25.0°
Moderately unstable	B	20.0°
Slightly unstable	C	15.0°
Neutral	D	10.0°
Slightly stable	E	5.0°
Moderately stable	F	2.5°
Extremely stable	G	1.7°

* Standard deviation of horizontal wind direction fluctuation over a period of 15 minutes to 1 hour. The values shown are averages for each stability classification.

(i.e., σ_θ, σ_w) controls diffusion and turbulence is not always related uniquely to ΔT in airflows over rough topography.

Table III-2 indicates that when the whole second year is considered, stability classes D and E (neutral and slightly stable, respectively) are most prevalent on the tracts. At Station A2, the frequency of occurrence of either the unstable classes A and B or of high-stability (classes F and G) is very small. This is again attributed to its sheltered location. At the highly exposed Station A4, stability classes F and G occur most frequently in winter and stability class A and B occur most frequently in summer. Data collected at Station A6 show that stability classes are most variable with atmospheric condition in winter, with the overall pattern still tending toward stability, however.

3. INTERPRETATION AND CONCLUSIONS

The following was concluded from the two years of monitoring.

Conditions adverse to mixing occur most frequently in winter and least frequently in summer.

In such adverse conditions (low winds, low inversion heights), the dispersion in the sheltered, large canyons of Tract U-a is significantly poorer than in the more open, rolling country of Tract U-b.

The typical diffusivity values are around 0.2-0.4 m/s.

The most frequently occurring atmospheric conditions, on an annual basis, are stability classes D and E (neutral and slightly stable).

There was no significant differences between the First and Second year.

C. AIR QUALITY

Data collected in the second year of baseline monitoring reinforced the first-year conclusion that air quality on the tracts is representative of a naturally occurring background air environment because of the lack of significant anthropogenic sources of air contaminants in the area.

1. GASEOUS POLLUTANTS

a. Methodology

From data collected in the first year of baseline monitoring, it was determined that the coefficient of haze measurements were not needed after January 1976, and such measurements were terminated then. It was also determined that air quality conditions in the area were quite uniform and that the monitoring network originally designed was in excess of what was required. Consequently, changes were made in May 1976 with the approval of the AOSS. These changes included the following:

termination of air quality monitoring (H_2S , SO_2 , and suspended particulates) at Station A1, which was some distance upwind from the tracts and had provided only redundant data

termination of SO_2 , H_2S , suspended particulate, NO_2 , HC, CO and O_3 measurements at Station A2 because of data redundancy

termination of NO_2 , HC, CO and O_3 measurements at Station A3 because of data redundancy

termination of all air quality monitoring (H_2S , SO_2 , and suspended particulates) at Station A5 because of data redundancy

termination of all air quality monitoring (H_2S , SO_2 , and suspended particulates) at Station A8 because of data redundancy and its distance from likely impact areas

Figure III-12 shows locations of all air quality measurement stations.

b. Summary of Results

For reference in the ensuing discussion, Table III-4 gives the Federal National Ambient Air Quality Standards (NAAQS) for the various gaseous pollutants monitored on the tracts. There are no Utah state air quality standards for gaseous pollutants, and there are no standards, either state or federal, for H_2S ; a reference for interpreting the data is the California 1-hour standard of $42 \mu\text{g}/\text{m}^3$ (0.03 ppm).

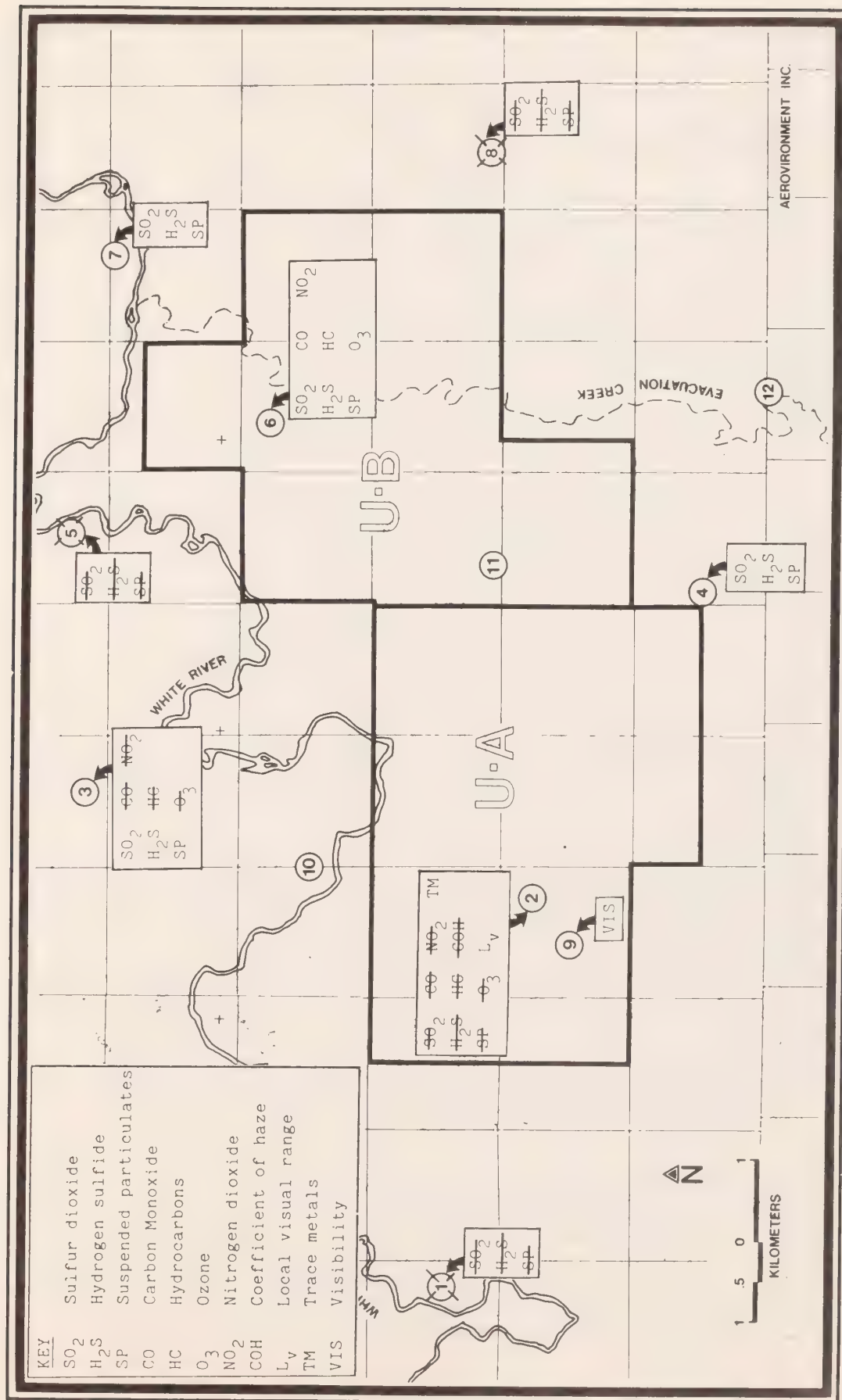


FIGURE III-12.

LOCATIONS OF AIR QUALITY MEASUREMENT STATIONS ON TRACTS U-a AND U-b. Stations that are crossed out were terminated in May 1976. Parameters at Stations A2 and A3, except COH, were not monitored after May 1976. COH at Station A2 was not measured after January 1976.

TABLE III-4. FEDERAL AIR QUALITY STANDARDS FOR GASEOUS POLLUTANTS.

Pollutant	Averaging Time	Primary Standards	Secondary Standards
Ozone (O_3)	1 hour	$160 \mu\text{g}/\text{m}^3$ (0.08 ppm)	Same as primary
Carbon Monoxide (CO)	8 hours	$10 \text{ mg}/\text{m}^3$ (9 ppm)	Same as primary
	1 hour	$40 \text{ mg}/\text{m}^3$ (35 ppm)	Same as primary
Sulfur Dioxide (SO_2)	Annual Average	$80 \mu\text{g}/\text{m}^3$ (0.03 ppm)	-
	24 hour	$365 \mu\text{g}/\text{m}^3$ (0.14 ppm)	-
	3 hour	-	$1300 \mu\text{g}/\text{m}^3$ (0.5 ppm)
Nitrogen Dioxide (NO_2)	Annual Average	$100 \mu\text{g}/\text{m}^3$ (0.05 ppm)	Same as primary
Hydrocarbons (corrected for methane - NMHC)	3 hour (6-9 a.m.)	$160 \mu\text{g}/\text{m}^3$ (0.24 ppm)	Same as primary

SOURCE: National Primary and Secondary Ambient Air Quality Standards - Federal Register, Vol. 36, Number 84, Washington, D.C., April 30, 1971.

In this section, data are discussed only for stations that were not terminated in May 1976. As will be discussed later, air quality was determined to be uniform throughout the tracts, and therefore presentation of a full year of data for stations that operated for the full year is sufficient to describe conditions on the tracts.

With respect to most of the gaseous pollutants, the air quality in the two-tract area has been exceptionally good, which is to be expected because of their remote location. All pollutants were present at measurable quantities in the beginning of the monitoring program when well-drilling and set-up activities were carried out by various participating groups. As the program settled down to routine baseline monitoring, most of the pollutant concentrations dropped to the threshold limits of the instruments. The gaseous pollutants that still showed variations and were at levels of interest were ozone and non-methane hydrocarbons (NMHC). Only the 6 a.m. to 9 a.m. federal ambient air quality standard for NMHC was exceeded during the second year of baseline monitoring, though both ozone and NMHC exceeded standards during the first year.

Table III-5 gives statistics on 6 a.m. to 9 a.m. NMHC readings at Station A6 for the four quarters of 1976. This table shows that the highest reading was recorded in summer ($1040 \mu\text{g}/\text{m}^3$). The average readings were lowest in fall and highest in spring. Several NMHC readings exceeded the standard ($160 \mu\text{g}/\text{m}^3$): out of a total of 308 observations, 20 were in excess of the standard. For purposes of comparison, Table III-6 shows the peak 6 a.m. to 9 a.m. NMHC readings recorded during the first year of baseline monitoring at stations A2, A3, and A6.

There are some possible explanations for so many exceedances of standards. First, the precision of NMHC measurements is questionable. Recent tests by the EPA of the prescribed reference method of determining NMHC (gas chromatographic separation of methane from the total hydrocarbons measured by flame ionization, allowing computation of NMHC) has shown instrument precision limitations. The combination of detection limit and equipment accuracy can be as large as $\pm 130 \mu\text{g}/\text{m}^3$ (see Table III-7). This is very close to the NAAQS value of $160 \mu\text{g}/\text{m}^3$. Second, there could be hydrocarbon sources in the area, including vegetation types that release a variety of organic substances.

It should be noted that the federal standard for NMHC of $160 \mu\text{g}/\text{m}^3$ (0.24 ppm) for the 3-hour period of 6 a.m. to 9 a.m. was established to reduce the formation of photochemical pollutants (for which separate standards exist also) and not as a health standard per se. Comparing each of the NMHC readings exceeding the standard with the corresponding daily oxidant peak (Table III-8), however, did not reveal any noticeable relationship

TABLE III-5
NMHC READINGS - 1976

Station	Quarter	Peak Hour ¹	Second Highest	Average	Number of Obs.	Percent Exceedance of Standard ²
A-6	Winter ³	210	190	85	48	10.4
	Spring	340	280	95	89	7.9
	Summer	1040	930	65	84	4.8
	Fall	310	270	35	87	4.4

¹Peak Hour 0600 - 0900 MST

²Standard is 160 g/m

³Winter includes the period January 16, 1976 through February 29, 1976 and December 1, 1976 through January 15, 1977

TABLE III-6
NMHC READINGS - 1975

Station	Quarter	Peak Hour ¹	Second Highest	Average	Number of Obs.	Percent Exceedance of Standard ²
A-2	Winter ³	400	360	80	48	12
	Spring	100	70	8	83	0
	Summer	490	380	46	44	11
	Fall	260	250	25	79	4
A-3	Winter ³	1680	1640	1190	12	100
	Spring ⁴	--	--	--	0	--
	Summer	1960	1640	170	50	8
	Fall	1470	1370	170	41	20
A-6	Winter ³	1220	1090	320	63	56
	Spring	1400	930	260	78	40
	Summer	380	360	300	11	100
	Fall	300	290	90	49	10

¹Peak Hour is 0600 - 0900 MST

²Standard is 160 $\mu\text{g}/\text{m}^3$

³Winter includes December 1974 through February 1975

⁴No data was collected in that quarter due to an instrument problem

TABLE III-7

ESTIMATED RMS ACCURACY OF MAJOR AIR QUALITY MEASUREMENTS

Component	Calibration Accuracy (1)	System (1) Accuracy(2)	Total Accuracy (1)
SO ₂	± 5% or 2 ppb	± 5% or 3 ppb	±7% or 4 ppb (11 µg/m ³)
H ₂ S	± 10% or 5 ppb	± 6% or 6 ppb	±12% or 8 ppb (11 µg/m ³)
Suspended Particulates	--	± 1 µg/m ³	±1 µg/m ³
O ₃	± 5% or 0.01 ppm	± 2% or 0.005 ppm	±5 % or 0.01 ppm (20 µg/m ³)
NO, NO _x	± 5% or 0.01 ppm	± 3% of 0.01 ppm	±6% or 0.01 ppm (20 µg/m ³)
NO ₂ (3)	--	± 4% or 0.01 ppm	±6% or 0.02 ppm (40 µg/m ³)
THC, CH ₄	± 2% or 0.1 ppm	± 2% or 0.1 ppm	±3% or 0.1 ppm (65 µg/m ³)
NMHC (4)	± 2% or 0.1 ppm	± 3% or 0.1 ppm	±4% or 0.2 ppm (135 µg/m ³)

Notes:

- (1) The larger of the values given applies.
- (2) Total for all portions, including installation, recorder, and readout.
- (3) Including subtraction of NO from NO_x during data reduction
- (4) Including subtraction of CH₄ from THC during data reduction

between the high levels of each. Peak oxidant readings in Table III-8 are typical daily peaks, implying that unusually high NMHC readings between 6-9 a.m. did not increase the daily oxidant peak.

There were no readings of oxidants in excess of the standard during the second year. Table III-9 presents the highest, second highest, and average readings for each season in 1976 at Station A6. Seasonal and diurnal variations in the concentrations of this pollutant are evident. Highest readings were observed in summer and the lowest in fall.

Figure III-13 shows ozone concentrations as a function of time of day in July. This diurnal trend is typical for all seasons, with the highest daily peak anywhere in the afternoon and the daily minimum at around 0500-0600.

Although no concentrations exceeding the oxidant standard were observed in 1976 the summer peak was 87% of the standard. Furthermore, 42 hourly average concentrations in excess of the standard were observed during the first year of monitoring. First-year ozone concentrations are summarized in Table III-10.

It is interesting to note that all the measured exceedances during the first year occurred at A-2. The highest corrected value measured was $190 \mu\text{g}/\text{m}^3$ versus the standard of $160 \mu\text{g}/\text{m}^3$. This apparent uniqueness of A-2 was attributed to the A-2 ozone equipment characteristics, and not to any spatial variation in ozone concentrations across the tracts.

The typical system accuracy for ozone measurements is $\pm 20 \mu\text{g}/\text{m}^3$ (see Table III-7). Applying the high side of this accuracy range to the peak values shown on tables III-9 and III-10, all monitoring sites approached or exceeded the standard of $160 \mu\text{g}/\text{m}^3$ during the first year and A-6 exceeded the standard during the second year. This implies that even with no significant anthropogenic activities, the oxidant level is quite high, regardless of specific monitoring site equipment characteristics, and from year to year the standard would be either exceeded or approached.

Carbon monoxide, a common pollutant in urban areas, was almost non-existent on the tracts. Table III-11 shows the peak, second highest, and average 1-hour and 8-hour CO concentration at Station A6 in 1976. The highest hourly average reading and the highest 8-hour average were $3.0 \text{ mg}/\text{m}^3$ and $2.7 \text{ mg}/\text{m}^3$, respectively, in summer 1976. These peak readings were well below the federal 1-hour standard of $40 \text{ mg}/\text{m}^3$ or the 8-hour standard of $10 \text{ mg}/\text{m}^3$. The peak 1-hour and 8-hour CO concentra-

TABLE III-8. A COMPARISON OF NMHC READINGS EXCEEDING THE
STANDARD WITH CORRESPONDING DAILY OXIDANT PEAKS.

Date of Observation	6-9 a.m. NMHC Reading	Daily Oxidant Peak
2/29	177	80
3/8	280	100
3/9	200	110
3/13	210	90
3/17	170	80
5/2	180	80
5/7	340	90
5/12	200	110
6/30	360	100
7/1	1040	90
7/2	930	120
8/10	260	70
9/24	260	60
9/26	270	70
11/3	170	60
11/25	310	70
12/23	180	80
12/24	210	100
12/30	190	90
1/15	170	70

TABLE III-9
OZONE READINGS - 1976
($\mu\text{g}/\text{m}^3$)

Station	Quarter	Peak Hour	Second Highest	Average	Number of Obs.	Percent Exceedance of Standard ¹
A-6	Winter ²	120	120	60	1947	0
	Spring	130	130	70	2192	0
	Summer	140	140	70	2101	0
	Fall	90	90	50	2159	0

¹Standard is 160 g/m

²Winter season includes the period January 16 through February 29, 1976 and December 1, 1976 through January 15, 1977

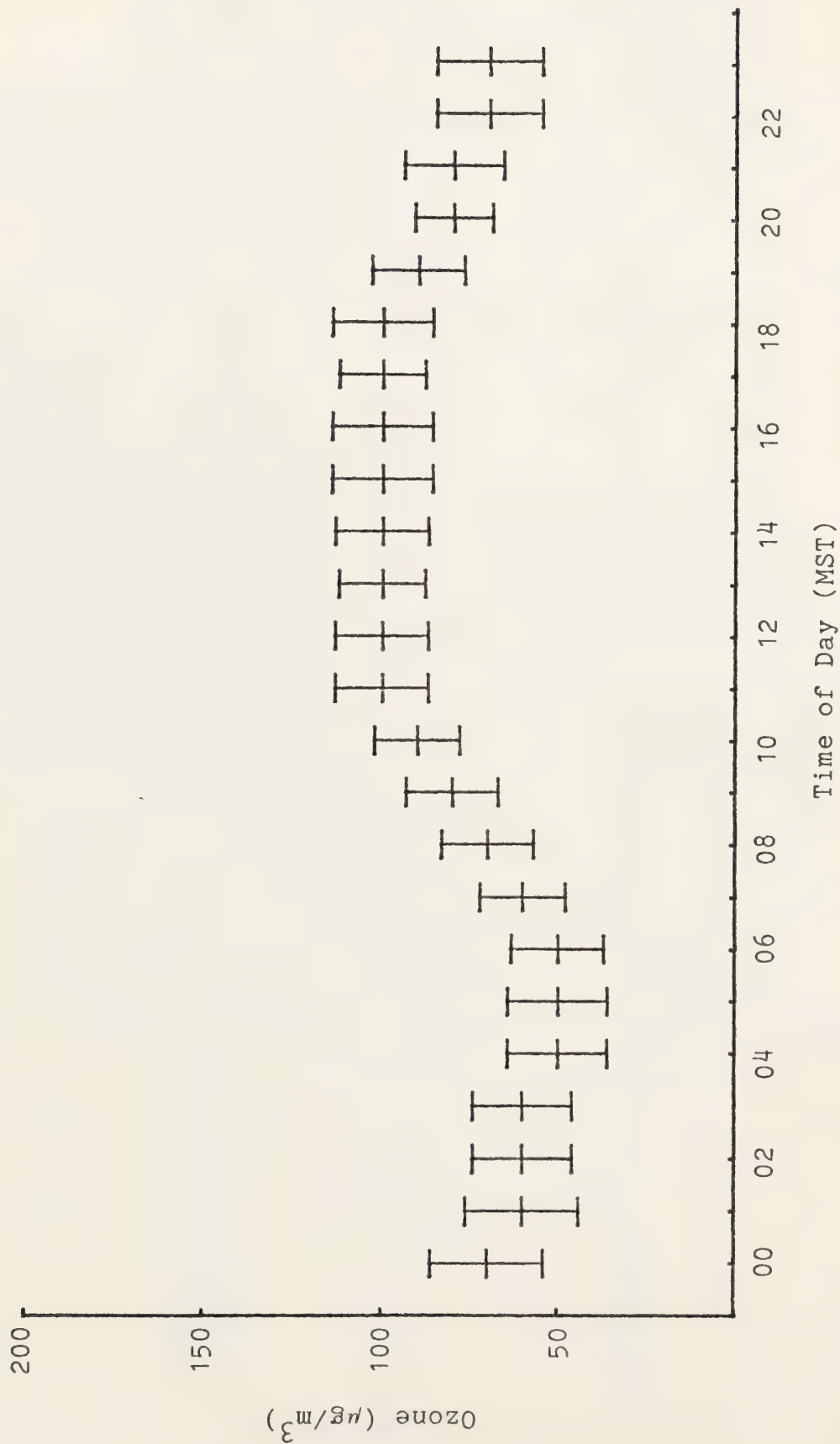


FIGURE III-13. DIURNAL VARIATION IN MEAN OZONE CONCENTRATIONS WITH THEIR STANDARD DEVIATIONS AT STATION A6 IN JULY 1976.

TABLE III-10
OZONE READINGS - 1975
($\mu\text{g}/\text{m}^3$)

Station	Quarter	Peak Hour	Second Highest	Average	Number of Obs.	Percent Exceedance of Standard ¹
A-2	Winter ²	120	120	40	820	0
	Spring	190	180	110	1017	1.4
	Summer	180	180	110	1749	1.6
	Fall	130	130	60	2141	0
A-3	Winter ²	130	130	70	2082	0
	Spring	150	150	90	1733	0
	Summer	140	140	70	1813	0
	Fall	140	140	80	1305	0
A-6	Winter ²	150	150	80	945	0
	Spring	150	140	80	1841	0
	Summer	130	130	80	2034	0
	Fall	140	130	60	2085	0

¹Standard is 160 $\mu\text{g}/\text{m}^3$

²Winter includes December 1974 through February 1975

TABLE III-11.

THE PEAK, SECOND HIGHEST AND AVERAGE CARBON MONOXIDE CONCENTRATIONS (mg/m³) AS WELL AS THE PERCENT OF OBSERVATIONS EXCEEDING STANDARDS AT STATION A6 IN 1976.

Season	Averaging Time	Peak Concentration	Second Highest Concentration	Average	No. of Observations	Percent Exceedance ² of Standard ²
Winter ¹	1-Hour	1.0	0.9	0.2	2160	0
	8-Hour	0.6	0.5	0.2	2184	0
Spring	1-Hour	0.7	0.6	0.1	2129	0
	8-Hour	0.3	0.3	0.1	2139	0
Summer	1-Hour	3.0	2.7	0.1	2038	0
	8-Hour	1.8	1.7	0.1	2052	0
Fall	1-Hour	1.2	1.2	0.1	2081	0
	8-Hour	0.3	0.3	0.1	2086	0

¹ Winter season includes the period 16 January - 29 February 1976 and 1 December 1976 - 15 January 1977.

² 1-hour standard is 40 mg/m³, 8-hour standard is 10 mg/m³.

tions recorded during the first year (1975) were 5.2 mg/m^3 and 3.9 mg/m^3 , respectively. These concentrations were recorded in January 1975 at Station A3 during the height of tract activities. No diurnal or seasonal variations were observed in the CO levels, and readings were generally near detection limit of the instrument, around 0.1 mg/m^3 .

Federal standards for nitrogen dioxide (NO_2) are written in terms of an annual average of $100 \text{ } \mu\text{g/m}^3$. The second-year annual average of NO_2 at Station A6 was $5 \text{ } \mu\text{g/m}^3$. During the first year of monitoring, annual averages of NO_2 at stations A2, A3, and A6 were 10, 5 and $5 \text{ } \mu\text{g/m}^3$, respectively.

Both sulfur dioxide (SO_2) and hydrogen sulfide (H_2S) behaved very much like CO. There were no significant diurnal or seasonal averages, and all readings were recorded near the detection thresholds of the instruments. Table III-12 presents the peak, second highest, and average SO_2 concentrations at stations A3, A4, A6, and A7 in 1976. The highest 3-hour SO_2 reading of $35 \text{ } \mu\text{g/m}^3$ was recorded at A3 in the fall. The standard for a 3-hour averaging time is $1300 \text{ } \mu\text{g/m}^3$. The highest 24-hour SO_2 reading ($25 \text{ } \mu\text{g/m}^3$) was also recorded at A3 in the fall. Again, this reading is well below the 24-hour standard of $365 \text{ } \mu\text{g/m}^3$. The annual average reading on the tracts is under $5 \text{ } \mu\text{g/m}^3$, compared to the annual standard of $80 \text{ } \mu\text{g/m}^3$. For purposes of comparison, the highest 3-hour and 24-hour SO_2 concentrations recorded during the first year of monitoring were $40 \text{ } \mu\text{g/m}^3$ (summer at A7) and $25 \text{ } \mu\text{g/m}^3$ (summer at A7), respectively. The annual average during 1975 ranged from 0 to $10 \text{ } \mu\text{g/m}^3$.

Table III-13 shows the peak, second highest, and average hourly concentrations of H_2S at stations A3, A4, A6, and A7 in 1976. The hourly average H_2S reading was under $5 \text{ } \mu\text{g/m}^3$. The highest reading was $30 \text{ } \mu\text{g/m}^3$ at A4 in spring. There are no federal or Utah state standards, but this highest reading is below the California standard of $42 \text{ } \mu\text{g/m}^3$.

c. Interpretation and Conclusions

Data collected during the second year of monitoring further substantiates findings presented in the FYEBR. These are reiterated as follows:

There are no significant spatial differences in pollutant concentrations. This is discussed in greater detail below.

6-9 a.m. NMHC standards are presently exceeded.

In the summertime, oxidant levels are very near the

TABLE III-12.

THE PEAK, SECOND HIGHEST AND AVERAGE SO₂ CONCENTRATION ($\mu\text{g}/\text{m}^3$) as well AS THE PERCENT OF OBSERVATIONS EXCEEDING STANDARDS AT STATIONS A3, A4, A6, AND A7 IN 1976.

Station	Season	Averaging Time	Peak Concentration	Second Highest Concentration	Average	No. of Observations	Percent Exceedance of Standards ²
A3	Winter ¹	3-Hour	10	10	5	1866	0
		24-Hour	10	5	5	81	0
	Spring	3-Hour	10	10	5	2101	0
		24-Hour	5	5	5	87	0
	Summer	3-Hour	15	15	5	1607	0
		24-Hour	10	10	5	75	0
	Fall	3-Hour	35	35	10	1717	0
		24-Hour	25	25	10	75	0
	Annual		--	--	5	1	0

TABLE III-12. (Continued)

Station	Season	Averaging Time	Peak Concentration	Second Highest Concentration	Average	No. of Observations	Percent Exceedance of Standards ²
A4	Winter ¹	3-Hour	5	5	0	1058	0
		24-Hour	0	0	0	45	0
	Spring	3-Hour	5	5	0	698	0
		24-Hour	0	0	0	53	0
	Summer	3-Hour	5	5	5	1998	0
		24-Hour	5	5	0	84	0
	Fall	3-Hour	5	5	0	1975	0
		24-Hour	0	0	0	82	0
		Annual	--	--	0	1	0
A6	Winter ¹	3-Hour	5	5	0	2085	0
		24-Hour	5	0	0	87	0
	Spring	3-Hour	5	5	0	2085	0
		24-Hour	0	0	0	89	0
	Summer	3-Hour	5	5	0	1944	0
		24-Hour	0	0	0	82	0
	Fall	3-Hour	5	5	0	2079	0
		24-Hour	0	0	0	87	0
		Annual	--	--	0	1	0

TABLE III-12. (Continued)

Station	Season	Averaging Time	Peak Concentration	Second Highest Concentration	Average	No. of Observations	Percent Exceedance of Standards ²
A7	Winter ¹	3-Hour	15	15	5	2113	0
		24-Hour	10	10	5	89	0
	Spring	3-Hour	10	10	5	2075	0
		24-Hour	5	5	5	88	0
	Summer	3-Hour	10	10	5	1995	0
		24-Hour	5	5	0	84	0
	Fall	3-Hour	10	10	5	2113	0
		24-Hour	5	5	5	88	0
		Annual	--	--	5	1	0

¹ Winter season includes the period 16 January-29 February 1976 and 1 December 1976-15 January 1977.

² 3-Hour standard is $1300 \mu\text{g}/\text{m}^3$, 24-hour standard is $365 \mu\text{g}/\text{m}^3$, annual standard is $80 \mu\text{g}/\text{m}^3$.

TABLE III-13. THE PEAK, SECOND HIGHEST AND AVERAGE HOURLY AVERAGED H₂S CONCENTRATIONS (µg/m³) AT STATIONS A3, A4, A6 AND A7 FOR DIFFERENT SEASONS IN 1976.

Station	Season	Peak Concentration	Second Highest Concentration	Average	No. of Observations
A3	Winter ¹	10	10	5	2084
	Spring	5	5	0	2101
	Summer	10	10	0	1728
	Fall	20	20	5	1772
A4	Winter ¹	10	5	0	1062
	Spring	30	30	5	1293
	Summer	0	0	0	2014
	Fall	5	0	0	1990
A6	Winter ¹	5	5	5	2087
	Spring	10	5	5	2091
	Summer	5	5	0	1856
	Fall	5	5	0	2088
A7	Winter ¹	5	5	0	2119
	Spring	10	10	0	2106
	Summer	5	5	0	2009
	Fall	5	5	0	2119

¹

Winter includes the period 16 January 1976-29 February 1976 and 1 December 1976-15 January 1977.

standard, if not exceeding it. This is more obvious if the $\pm 20 \mu\text{g}/\text{m}^3$ total accuracy test is applied to the data (see Table III-7). CO, SO₂, and NO₂ levels are extremely low, around the detection thresholds of the respective instruments.

Except for oxidants, there are no noticeable diurnal variations in concentration of measured pollutants. Oxidant levels are usually highest in the afternoon and lowest just before dawn.

There were no significant differences between first-year and second-year data.

2. PARTICULATES AND TRACE METALS

a. Methodology

At the time the scope of the gaseous pollutant measurement program was changed, the AOSS also approved changes in the suspended particulate matter monitoring program. Particulate measurements were terminated at stations A1, A2, A5, and A8 in May 1976. All other activities were continued as described in the FYEBR.

b. Summary of Results

This discussion includes only data for the stations that were not shut down in May 1976, since these data are representative of the overall condition on the tracts. Table III-14 gives the annual quarterly geometric means, quarterly standard geometric deviations, and maximum and minimum readings at stations A3, A4, A6, and A7 in the last four quarters. Because particulate concentrations have been found to be log-normally distributed, the geometric mean presented can be considered to correspond to the concentration expected at a 50% frequency.

Particulate matter on the tracts comes primarily from wind-blown dust and vehicles traveling on unpaved roads. Data indicate that particulate concentrations on the tracts vary seasonally and spatially. Concentrations were lowest during winter because the snow cover on the ground kept dust and fine soil particles from entering the atmosphere by wind and vehicle activity. In contrast, particulate concentrations were highest in summer and fall.

The geometric mean ranged from $10 \mu\text{g}/\text{m}^3$ at Station A3 in winter to $37 \mu\text{g}/\text{m}^3$ at Station A6 in fall. The highest concentration

TABLE III-14. PARTICULATE CONCENTRATIONS - QUARTERLY GEOMETRIC MEANS, STANDARD GEOMETRIC DEVIATIONS, AND MAXIMUM, MINIMUM AND ANNUAL GEOMETRIC MEANS ($\mu\text{g}/\text{m}^3$ IN 1976.

Station	A3	A4	A6	A7
Geometric Mean				
Winter ¹	10.0	11.0	14.2	13.3
Spring	10.9	17.9	17.2	15.8
Summer	21.4	19.2	34.8	15.3
Fall	13.5	17.0	37.1	16.6
Std. Geo. Dev.				
Winter ¹	1.9	1.7	2.6	1.8
Spring	1.9	1.8	1.9	2.0
Summer	1.4	2.4	1.4	2.1
Fall	1.7	1.7	1.9	1.8
Maximum				
Winter ¹	22.7	23.3	51.9	23.7
Spring	39.5	63.8	45.1	77.7
Summer	35.7	60.5	63.9	37.3
Fall	25.3	34.6	101.2	42.1
Minimum				
Winter ¹	2.6	4.7	3.5	3.3
Spring	4.5	7.3	4.9	6.6
Summer	12.2	5.3	18.7	3.3
Fall	5.2	6.0	7.6	5.3
Annual Geo. Mean	13.3	15.9	23.5	15.2
Annual Std. Geo. Deviation	1.8	1.9	2.2	1.9

¹ Winter includes the period 16 January 1976-29 February 1976 and 1 December 1976-15 January 1977.

observed was $101 \mu\text{g}/\text{m}^3$ at Station A6 in the fall, and the lowest concentration of $2.6 \mu\text{g}/\text{m}^3$ was recorded at Station A3 in winter.

None of the recorded values exceeded federal or state standards, which are given on Table III-15. The most stringent short-term standard is the National Secondary Standard, which sets the upper limit at $150 \mu\text{g}/\text{m}^3$ averaged over 24 hours; this is not to be exceeded more than once a year.

A set of size-fractionated particulate samples was collected every month at Station A2 by means of a multistage Lundgren impactor for analysis of trace elements using ion-excited x-ray emission techniques at 50 microcoulombs. Analysis results indicate the presence of Li, Be, B, Na, Mg, Al, Si, S, Cl, K, Ca, Ti, V, Cr, Mn, Fe, Co, Ni, Cu, Zn, As, Se, Br, Rb, Sr, Zr, Ba, Pt, Au, Hg, and Pb. Most of the elements, with the exception of normal soils constituents, were found at concentrations less than or around $10 \text{ ng}/\text{m}^3$, with most of the mass generally found in the smaller size fractions ($.10-.65 \mu\text{m}$). The elements that existed in larger quantities were Al, Si, S, K, Ca, and Fe. Concentrations of typical anthropogenic aerosols, such as Cu, Zn, and the automotive-derived aerosols of Br and Pb, were very low -- only a small percentage of typical urban values.

c. Interpretation and Conclusions

Particulate concentrations remained the same during the first and second year of monitoring. They were typical of rural areas, where dusts are generated primarily from wind and vehicles traveling on unpaved roads. Particulate concentrations were lower when the ground was covered with snow. There are presently no concentrations exceeding any suspended particulate standards. Trace metals present in the air are mostly of soil origin, indicating the absence of human activities.

Particulate concentrations varied spatially on the tracts. This site-to-site variability, however, was attributed to the variety of vehicular activities on unpaved roads near these stations. Logically, the eight high volume-sampler sites originally set up can be grouped into three classes.

Four sites were sufficiently removed from all local roads to be considered truly background locations - Sites A1, A2, A3, and A7.

Two sites were near (within 100 m) very lightly traveled unpaved roads (less than 20 cars/day average) - Sites A4 and A8.

TABLE III-15 AMBIENT AIR QUALITY STANDARDS FOR PARTICULATE
MATTER ($\mu\text{g}/\text{m}^3$).

Pollutant	Averaging Time	Utah Standards	National Standard ¹	
			Primary	Secondary
Suspended Particulate Matter	Annual Geometric Mean	90	75	60
	24 Hour	200	260	150

(1) National Primary and Secondary Ambient Air Quality Standards-
Federal Register, Vol. 36, Number 84, Washington, D.C.,
April 30, 1971.

Note: The State of Utah has adopted the Federal Particulate
Standards (Utah Air Conservation Regulations as re-
vised July 9, 1975, State of Utah, Department of
Social Services, Division of Health).

- c) Two sites were near (within 100 m) more heavily traveled unpaved roads (up to 50 cars/day average) - Sites A5 and A6.

3. VISIBILITY

A. Methodology

No changes were made during the second year of monitoring. The program as described in FYEBR was continued in 1976.

b. Summary of Results

An integrating nephelometer monitored the local clarity of the air at Station A2 in terms of a scattering coefficient, which was converted to a local visual range, assuming a 2% contrast threshold for the eye. Table III-16 shows the maximum, minimum, and average local visual range values computed from the integrating nephelometer data during the second year. The highest scattering recorded during 1976 was $b_s = 0.22 \times 10^{-3} \text{m}^{-1}$, which was observed in the spring and corresponds to a local visual range of 21 km (13 miles). The most clear hours had $b_s = 0.02 \times 10^{-3} \text{m}^{-1}$ (visual range 235 km, or 146 mi), which was observed in all seasons and corresponds to the visibility in particle-free air. The majority of observed values corresponded to extremely clear, background quality air. A very weak diurnal variation in scattering coefficient was observed, with the night and early morning hours showing slightly higher scattering (lower visibility) than the afternoon and evening hours.

Photographic visibility measurements were made on a scheduled basis. Photographs taken on August 2, 1976, are shown on Figure III-14 as examples of the views during the baseline monitoring period. The selected views show the farthest landmarks visible from the photography site. To the northwest the farthest landmark is the Uinta Mountains west of Vernal, which are about 130 km from Station A9. To the northeast, Blue Mountain, at 60 km, is the farthest landmark. In the originals of these photographs, the Uinta Mountains are still distinguishable and Blue Mountain is quite clear, indicating a visual range in excess of 130 km. The integrating nephelometer at A2 recorded a local visual range of 196 km at the same time, and thus the two measurement techniques are consistent. Although visibility was not always quite this good, none of the other days when photographs were taken demonstrated any significant obstructions to visibility,

TABLE III-16 MAXIMUM, MINIMUM, AND AVERAGE LOCAL VISUAL RANGE
VALUES (IN KM) ON THE TRACTS IN 1976).

	Maximum	Minimum	Average	No. of Observations
Winter	235	46	122	2184
Spring	235	21	145	2205
Summer	235	67	131	2206
Fall	235	50	126	2184



Two visibility measurement photographs taken at 1600 on 2 August 1976. The top view, to the northwest, faintly shows the Uinta Mountains (arrow) some 130 km distant to the east of Vernal. The bottom view, to the northeast, clearly shows Blue Mountain (arrow) at a distance of 60 km.

PHOTOGRAPHIC VISIBILITY RECORD

FIGURE III-14

either. It should be pointed out that the photography days were preselected to occur on a regular schedule and were not tailored to the weather.

c. Interpretation and Conclusions

Both the integrating nephelometer readings and photographs taken during the two years of monitoring indicate that there was excellent clarity in the atmosphere throughout the year. This is in agreement with other air quality measurements and demonstrates the lack of man-made haze in the area.

D. RADIOACTIVITY

1. METHODOLOGY

Ambient radioactivity measurements by pressurized ion chamber and hand-held radiation monitor were terminated in January 1976 with the approval of the AOSS. Monitoring by thermoluminescent dosimeters at Stations A1 through A12 and analysis of particulates for gross alpha and beta activity, and isotopic gamma analyses as described in the FYEBR continued through the second year of monitoring.

2. SUMMARY OF RESULTS

The radioactivity dosages measured for each season are tabulated on Table III-17. The dosages at each station were quite consistent throughout the year. The average dosage on the tracts was around 11 mR. Stations A1, A3, A5, and A8, located farthest from the tracts, exhibited lower than average dosages -- about 9 mR -- while Stations A2 and A11 on the tracts exhibited higher than average dosages -- about 13 mR. Readings of 9-14 mR, however, are in the normal ambient range.

Analysis of particulate matter collected on the high-volume sampler filters at Station A6 in 1976 indicate that gross alpha and beta readings were all below 0.1 pCi/m^3 except in November 1976, when the gross beta reading was around 0.6 pCi/m^3 . Quantitative gamma scans reveal the presence of K^{40} , Cs^{137} , Be^7 , Pb^{212} , Pb^{214} , Ra^{226} , Bi^{214} , Tl^{208} , Mn^{54} , Ce^{141} , Ce^{144} , Nb^{95} , Zr^{95} , Ba^{140} , Ru^{103} , La^{140} , Ac^{228} , and Cr^{51} at one time or another, with Cs^{137} and Be^7 on almost every filter. All readings, however, were below 0.35 pCi/m^3 .

TABLE III-17. AVERAGE RADIATION LEVELS (mR) AT ALL STATIONS IN 1976 AS MEASURED BY THREE THERMOLUMINESCENT DOSIMETERS AT EACH STATION.

Station	Winter 1/33/76 to 2/22/76 & 11/17/76 to 1/10/77	Spring 2/22/76 to 5/22/76	Summer 5/22/76-8/20/76	Fall 8/20/76-11/17/76
A1	9	9	9	10
A2	12	13	14	12
A3	9	9	9	10
A4	11	12	13	13
A5	8	8	9	9
A6	11	11	12	13
A7	11	11	11	11
A8	8	8	9	10
A9	10	10	10	11
A10	9	10	11	10
A11	12	13	14	14
A12	10	10	12	12

3. INTERPRETATION AND CONCLUSIONS

The two years of measurements show that there is no significant radioactivity in the air on the tracts.

E. SOUND LEVELS

No measurements were taken in 1976. Data collected during the first year is discussed in the FYEBR. In summary, the average sound levels observed in all seasons were in the range of 24 to 26 da (A), which is representative of a quiet residential bedroom (ie 25 to 30 db (A)).

F. EVALUATION OF BASELINE PROGRAM

The two-year air resources baseline monitoring program was begun January 16, 1975, and was completed January 15, 1977. During this period, all the stipulations in the lease and subsequent changes approved by the AOSS were followed.

The lessee established a meteorological station on each tract within reasonable proximity to the proposed plant site and in compliance with the original lease stipulations. Monitoring was conducted for the required meteorological parameters, which included wind speed and direction at three levels (10m, 20m, and 30m), temperature at two levels (10m and 30m), and humidity (determined from dewpoint and temperature data) at one level. Seasonal percentages have been discussed in previous quarterly reports.

Air quality parameters were monitored at four strategically-located stations on each tract. The lessee monitored for sulfur dioxide, hydrogen sulfide, and suspended particulates, using automatic instruments with continuous recorders when applicable. In addition, the lessee monitored hydrocarbons, carbon monoxide, oxides of nitrogen, and ozone under the same conditions and as determined by the AOSS.

In addition to complying with the original lease stipulations, the lessee also complied with the lease amendments of June 1, 1976. The lessee collected baseline data sufficient to define the existing environment as a baseline against which to compare future changes and to define the meteorological factors which might influence the transport and diffusion of pollutants. Data acquisition was for the greatest practicable period of time, and a quality assurance program was established and utilized throughout the two-year baseline monitoring period.

In retrospect, the original air resources program stipulated in the leases was in excess of what was required to define baseline air quality conditions. The data gathered during the first year of monitoring indicate that air quality is quite uniform on the tracts and that pollution levels except for ozone and non-methane hydrocarbons are generally very low. Except for ozone, non-methane hydrocarbon, and particulate matter, concentration levels of pollutants were usually near the threshold of detection of state-of-the-art instrumentation.

On the other hand, the requirements of the lease on the measurements of meteorology would, in some ways, have been insufficient to characterize the meteorology on the tracts, because of the high degree of spatial variability of surface flows. The actual monitoring that was conducted, however, was adequate and demonstrated that there was considerable spatial variability in different meteorological parameters on the tracts.

Most of the instruments used during the two-year program were accurate within the tolerable error limits for the parameters monitored. There were two exceptions, however, whose operational accuracy limits influenced the interpretation of their data: the hydrocarbon analyzers at stations A2, A3, and A6, and the temperature-difference systems (ΔT) on the 30-m towers at stations A2 and A6.

The r.m.s. precision of the Beckman gas chromatograph for the analysis of hydrocarbons is about 0.15 ppm for THC (total hydrocarbon) and also 0.1 ppm for CH_4 (methane). To obtain NMHC, the CH_4 reading is subtracted from the THC reading. This compounds the r.m.s. error to about 0.2 ppm, and considerably larger errors are possible on a sample-to-sample basis. Since the NMHC ambient air quality standard is 0.24 ppm, the instrumentation precision is almost equal to the standard, even if perfectly calibrated. However, the EPA-prescribed reference method for measuring non-methane hydrocarbons is by flame ionization detection and gas chromatography, exactly as used during the program were the best available. This relationship between the ambient air quality standard and the instrumentation technique is recognized by the EPA. From the perspective of the baseline monitoring program, the significance of the occasional large NMHC values observed should be evaluated recognizing the instrumentation characteristics discussed above.

The total accuracy of the ΔT system was $\pm 0.15^\circ\text{C}$. This system was set up to measure temperature differences over a distance of 20 m (between the 10m and 30m levels in the tower). This means an accuracy of $\pm 0.75^\circ\text{C}/100\text{m}$. This accuracy is not adequate to define atmospheric stability conditions according to the stability classification scheme in Atomic Energy Safety Guide 23 (AEC 1972), which requires an instrument accuracy of $\pm 0.1^\circ\text{C}/100\text{m}$. To some degree, this equipment inadequacy is

not important, however, since the diffusivity of the atmosphere can be more directly defined by measurement of the turbulent wind fluctuations. This was the approach used to characterize baseline conditions. Thus, the deficiency of the ΔT system did not affect the description of diffusivity on the tracts.

The sound level and radiation programs appeared to be of the proper scope to adequately describe the baseline conditions on the tracts.

Overall, data collected during the two years of monitoring was adequate to characterize baseline conditions of the air environment in the area of Tracts U-a and U-b.

Glossary

GLOSSARY

Acoustic radar: an instrument to measure the echo soundings of upper-atmospheric dispersive characteristics and atmospheric structure up to 1 km above the ground surface.

Anthropogenic: related to or the result of the activities of man.

Diffusivity: the quantity of a material passing through a given area per unit time.

Diurnal: pertaining to meteorological actions that are completed within 24 hours and that recur every 24 hours.

Gas chromatograph: an instrument used in gas chromatography to detect volatile compounds present; also used as a preparative technique for isolating pure components or certain fractions from a complex mixture.

Integrating nephelometer: an instrument that measures at more than one angle the scattering function of particles suspended in a medium; information obtained may be used to determine the coefficient of haze in the atmosphere.

Inversion: a departure from the usual decrease or increase with altitude of the value of an atmospheric property, most commonly temperature.

Particulates: fine solid particles that remain individually dispersed in gases and stack emissions.

Pressurized ion chamber: a particle detector that measures the ionization produced in the gas filling the chamber by the fast-moving charged particles as they pass through.

Rawinsonde: a method of upper-air observation consisting of an evaluation of the wind speed and direction, temperature, pressure, and relative humidity aloft by means of a balloon-borne radiosonde tracked by a radar direction finder.

Synoptic: refers to the use of meteorological data obtained simultaneously over a wide area for the purpose of presenting a comprehensive state of the atmosphere.

Trace metals: an extremely small but detectable quantity of a metal.

References

REFERENCES

MacCready et al. 1974. Diffusion and Turbulence Aloft Over Complex Terrain. Preprint Volume. Paper presented at the Symposium on Atmospheric Diffusion and Air Pollution, Santa Barbara, California, September 9-13. Boston: American Meteorological Society.

"National Primary and Secondary Ambient Air Quality Standards." Federal Register 36:34, April 30, 1971.



IV BIOLOGICAL RESOURCES



IV. BIOLOGICAL RESOURCES

The purpose of the biological resources investigations was to determine the distribution, density, and condition of the flora, and the species, distribution, and abundance of the fauna of Tracts U-a and U-b and within a 1.6-km (1-mi) perimeter around the tracts. The baseline data were collected over a two-year period to predict and evaluate the effects of oil shale development within the tracts, to develop plans for revegetation and fish and wildlife management, and to identify indicator species or parameters to use in the future to monitor the effects of development.

Four vegetation types were identified in the project area--sagebrush-greasewood, shadscale, juniper, and riparian. Within each vegetation type, five areas were selected in which to sample plant species, density, cover, height, and litter cover. Phenology and rooting characteristics and soil moisture were also observed and measured. Using big sagebrush as a key species, primary productivity was estimated from each current year's growth.

Twelve sampling sites were established (three in each vegetation type) to inventory and determine the distribution and relative abundance of terrestrial vertebrates. Each primary site (one per vegetation type) consisted of a flushing transect, rodent-trapping transect, and rodent-trapping grid. The other eight sites consisted of flushing and rodent-trapping transects. These sampling sites were monitored periodically throughout the two years. Deer, raptors, waterfowl, bats, beaver, predators, and livestock were sampled opportunistically.

Terrestrial invertebrates were sampled to determine species, relative abundance of the dominant orders, and interrelationships with other elements of the ecosystem. Three invertebrate sampling sites were established on the tracts to sample 15 abundant plant species.

Soils were sampled at four locations to determine the number and seasonal activity of microorganisms.

Aquatic biota were sampled at five stations along the White River (two beyond the 1.6-km perimeter) and one station on Evacuation Creek. Species composition, diversity, spatial and temporal distribution, relative abundance, and productivity were determined.

Biotic and abiotic data were also correlated to determine the structure and function of the ecology of the tracts and to define some of the significant and critical interrelationships between ecosystem components.

A. VEGETATION

Vegetation on the tracts were studied to identify the major vegetation types and their general distribution. Within each vegetation type the objectives were to determine structure and composition, including species, height, and density; record the stages of plant development; and assess the productivity of each vegetation type to determine production of annual and perennial species.

1. COMMUNITY STRUCTURE AND COMPOSITION

a. Methodology

Vegetation types were delineated after an extensive reconnaissance of Tracts U-a and U-b. Figure IV-1 shows the distribution of the four major vegetation types: sagebrush-grease-wood, juniper, shadscale, and riparian. This map was the basis for plant community analysis, productivity sampling, and wildlife studies.

The juniper vegetation type is characterized primarily by stands on moderate slopes grading out towards the canyon bottoms, primarily in the upper elevations of Tract U-a. Another phase of the juniper type is a very open and sparse stand that occupies the steep, rocky slopes and ledges. This phase was not sampled in the regular sampling program; however, a separate sampling program was developed to quantify some of the parameters of this sparse juniper phase.

The methods used to analyze community structure and composition followed those of the IBP Desert Biome Program at the Curlew Valley validation site in northeastern Utah. These methods are described in the First Year Environmental Baseline Report (FYEBR). To observe and compare peak vegetation for two years, field studies were conducted in June 1975 and June 1976 to emphasize the annual species and associated shrubs and in September 1974 and September 1975 for the perennial species (Figure IV-2). Pooling of data for each of the sampling periods was considered to increase the replication (size of n) (FYEBR), but a comparison of variances of key species at each of the sampling periods indicated that pooling would not be a valid procedure because of the considerable disparity among species variances.

The sampling procedures were basically the same throughout the baseline program, except for the following changes. The number of plots analyzed in June 1976 was doubled from 1975 to permit greater statistical accuracy and to accommodate

LEGEND

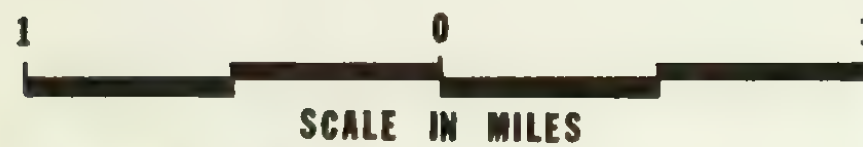
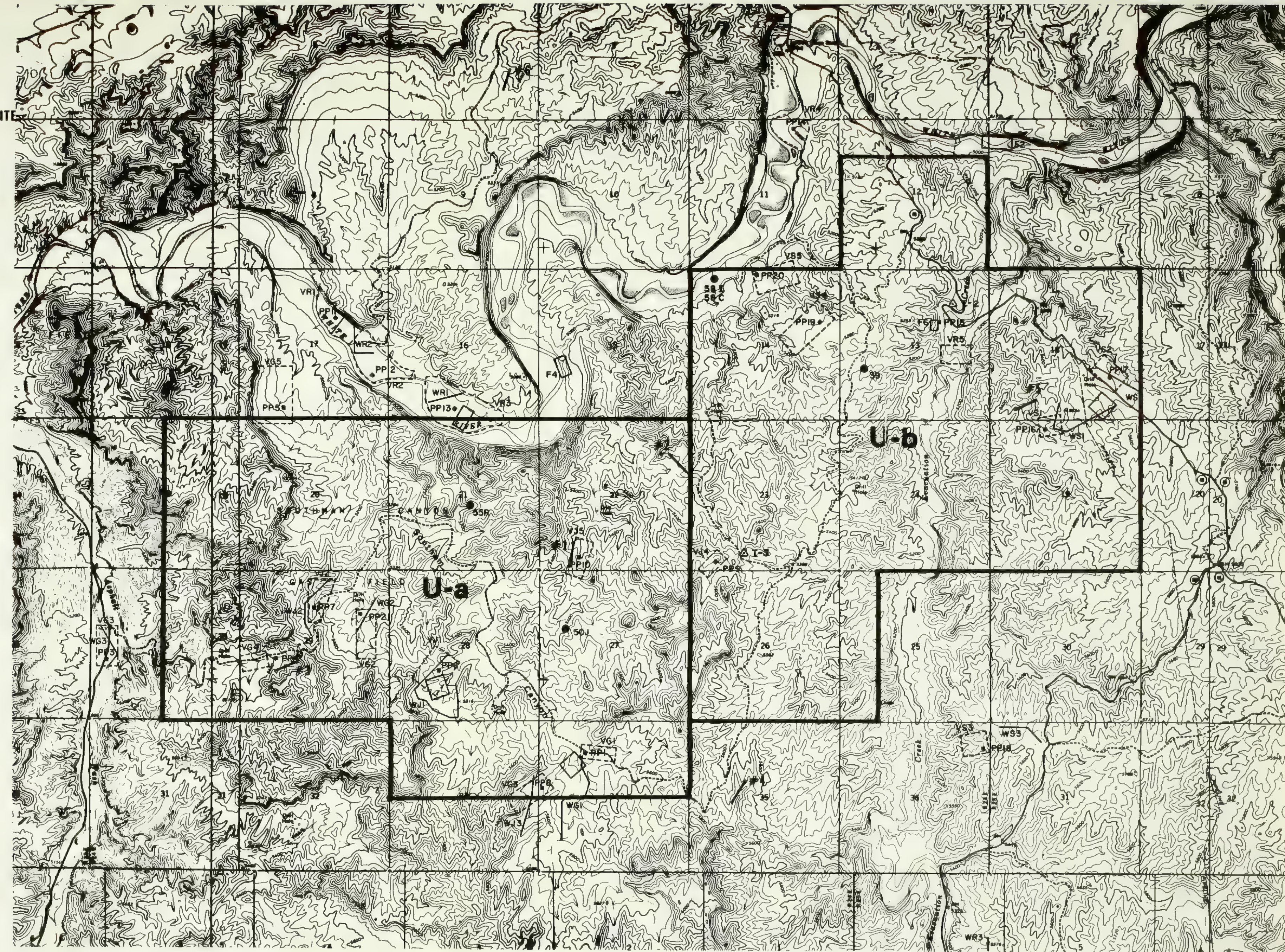
- 1 - SAGEBRUSH - GREASEWOOD
- 2 - JUNIPER
- 3 - SHADSCALE
- 4 - RIPARIAN



PHOTO MOSAIC; NOT TO SCALE

VEGETATION MAP

- SAGEBRUSH STEM GROWTH SAMPLING SITE
- MICROORGANISM SAMPLING STATION
- △ INVERTEBRATE SAMPLING STATION
- W WILDLIFE SAMPLING AREA
- V VEGETATION STUDY AREA
- G SAGE GREASEWOOD
- J JUNIPER
- R RIPARIAN
- S SHADSCALE
- F AQUATIC BIOLOGY SAMPLING STATION
- PP PERMANENT PLOT



BIOLOGICAL RESOURCE SAMPLING LOCATIONS

FIGURE IV-2



increased variability caused by much drier conditions in 1976 than in previous sampling periods. Seedlings of the major shrub and tree species were observed and recorded separately in spring 1976 to obtain a measure of reproduction. A seedling was defined as any small plant of a given species that appeared to be in the age class of one to four years.

Statistical treatment was used to characterize parameters rather than to analyze variance. Limits of central tendency of means were also defined. Data were reduced and analyzed to determine by species (1) the average number of plants occurring in a 4-m² plot; (2) the number of plots in which a given species occurred; (3) means for height, cover, and density; (4) 90% confidence interval about the mean; and (5) the sample size required to sample within 25% of the mean with a 90% statistical confidence.

For easier use of scientific names of plant species, a six-letter code was developed from the first three letters of the generic name and the first three letters of the species name. The six letters from the generic name were used where identification of the plant to the species level was impossible or doubtful because the required anatomical features were not discernible or a developmental stage had not been reached. When plants of sufficient maturity to discern the critical taxonomic characteristics were encountered during field sampling, a specimen was collected, pressed, mounted, and deposited in the Intermountain Herbarium at Utah State University.

b. Summary of Results

The species list and code designations are on Table IV-1. The list is not complete, because it is possible that there are species present on the tracts that were not encountered in this investigation.

Fall 1974

Sagebrush-greasewood: Fall 1974 sagebrush-greasewood data are analyzed on Table IV-2. In September 1974 approximately 10% of the ground surface in the sagebrush-greasewood type was covered by litter. Russian thistle (*Salsola kali*), greasewood (*Sarcobatus vermiculatus*), and big sagebrush (*Artemisia tridentata*) each covered about 1% of the ground surface, and the less dominant plant species collectively covered approximately 3%

TABLE IV-1
BOTANICAL SPECIES

Botanical species encountered on the tracts and adjacent areas and six-letter computer codes for scientific plant names.

<u>Six-Letter Plant Code</u>	<u>Scientific Name</u>	<u>Six-Letter Plant Code</u>	<u>Scientific Name</u>
ABRELL	<i>Abronia elliptica</i>	BARGRO	BARE GROUND
ABRFRA	<i>Abronia fragrans</i>	BASHYS	<i>bassia hyssopifolia</i>
ACHMIL	<i>Achillea millefolium</i>	BORAGI	<i>Boraginaceae</i> spp.
AGRINE	<i>Agropyron inerme</i>	BOUGRA	<i>Bouteloua gracilis</i>
AGRREP	<i>Agropyron repens</i>	BRICKE	<i>Brickellia</i> spp.
AGRSMI	<i>Agropyron smithii</i>	BROTEC	<i>Bromus tectorum</i>
ALLIUM	<i>Allium</i> spp.	CARYOP	<i>Caryophyllaceae</i> spp.
ALYDES	<i>Allyssum desertorum</i>	CASCHR	<i>Castilleja ohromosa</i>
AMBPSI	<i>Ambrosia psilostachya</i>	CENPAU	<i>Cenchrus pauciflorus</i>
AMEUTA	<i>Amelanchier utahensis</i>	CERLAN	<i>Ceratoides lanata (Eurotia lanata)</i>
AREKIN	<i>Arenaria kingii</i>	CIRSIU	<i>Cirsium</i> spp.
ARTEMI	<i>Artemisia</i> spp.	CHEALB	<i>Chenopodium album</i>
ARTFRI	<i>Artemisia frigida</i>	CHOTEN	<i>Chorispora tenella</i>
ARTLUD	<i>Artemisia ludoviciana</i>	CHRVIL	<i>Chrysopsis villosa</i>
ARTNOV	<i>Artemisia nova</i>	CHRGRE	<i>Chrysothamnus greenii</i>
ARTSPI	<i>Artemisia spinescens</i>	CHRNAU	<i>Chrysothamnus nauseosus</i>
ARTTRI	<i>Artemisia tridentata</i>	CHRVIS	<i>Chrysothamnus viscidiflorus</i>
ASCCRY	<i>Asclepias cryptoceras</i>	CIRSIU	<i>Cirsium</i> spp.
ASTCAN	<i>Astragalus canadensis</i>	CLELIG	<i>Clematis ligusticifolia</i>
ASTCON	<i>Astragalus convallarius</i>	CLELUT	<i>Cleome lutea</i>
ASTRAG	<i>Astragalus</i> spp.	CLESER	<i>Cleome serrulata</i>
ASTCYM	<i>Astragalus cymoides</i>	COMPAL	<i>Comandra pallida</i>
ASTMOLL	<i>Astragalus mollissimus</i>	CRUCIF	<i>Cruciferae</i> spp.
ASTSIM	<i>Astragalus simplifolius</i>	CRYAFF	<i>Cryptantha affinis</i>
ATRCAN	<i>Atriplex canescens</i>	CRYFLA	<i>Cryptantha flavoculata</i>
ATRCON	<i>Atriplex confertifolia</i>	CRYGRA	<i>Cryptantha gracilis</i>
ATRCUN	<i>Atriplex cuneata</i>	CRYGRM	<i>Cryptogam</i>
ATRARG	<i>Atriplex argentea</i>	CRYLON	<i>Cryptantha longiflora</i>
ATRIPL	<i>Atriplex</i> spp.	CRYPTA	<i>Cryptantha</i> spp.
ATRPAT	<i>Atriplex patula</i>	CRYSER	<i>Cryptantha sericea</i>
ATRPOW	<i>Atriplex powellii</i>	CYMOPT	<i>Cymopteria</i> spp.
BAIMUL	<i>Baileya multiradiata</i>	CYMACA	<i>Cymopterus acaulis</i>

TABLE IV-1
BOTANICAL SPECIES
(Cont.)

Six-Letter Plant Code	Scientific Name	Six-Letter Plant Code	Scientific Name
CYMFEN	<i>Cymopterus fendleri</i>	GRASPI	<i>Grayia spinosa</i>
DELBAR	<i>Delphinium barbeyi</i>	GRISQU	<i>Grindelia squarrosa</i>
DELPHI	<i>Delphinium</i> spp.	GUTSAR	<i>Gutierrezia sarothrae</i>
DESPIN	<i>Descurainia pinnata</i>	HALGLO	<i>Halopteron glomeratus</i>
DESSOP	<i>Descurainia sophia</i>	HEDBOR	<i>Hedysarum boreale</i>
DISSPI	<i>Distichlis spicata</i>	HILJAM	<i>Hilaria jamesii</i>
DISSTR	<i>Distichlis stricta</i>	HOLMIC	<i>Holodiscus microphyllus</i>
EPHVIR	<i>Ephedra viridis</i>	HORJUB	<i>Hordeum jubatum</i>
EQUARV	<i>Equisetum arvense</i>	HYMACA	<i>Hymenoxys acaulis</i>
ERIGER	<i>Erigeron</i> spp.	HYMENO	<i>Hymenoxys</i> spp.
ERIENG	<i>Erigeron engelmannii</i>	HYMSCA	<i>Hymenoxys scoposa</i>
ERIURS	<i>Erigeron ursinus</i>	IYAAXI	<i>Iva axillaris</i>
ERIOGO	<i>Eriogonum</i> spp.	JUNBAL	<i>Juncus balticus</i>
ERIBAT	<i>Eriogonum batemanii</i>	JUNOST	<i>Juniperus osteosperma</i>
ERICER	<i>Eriogonum cernuum</i>	KOCAME	<i>Kochia Americana</i>
ERIEFF	<i>Eriogonum effusum</i>	KOCHIA	<i>Kochia</i> spp.
ERIMIC	<i>Eriogonum microthecum</i>	KOCSCO	<i>Kochia scoparia</i>
ERIOVA	<i>Eriogonum ovalifolium</i>	KOCVES	<i>Kochia vestita</i>
ERIVIS	<i>Eriogonum viscidulum</i>	LAPRED	<i>Lappula redowskii</i>
EUPHOR	<i>Euphorbia</i> spp.	LEPIDI	<i>Lepidium</i> spp.
EUPFEN	<i>Euphorbia fendleri</i>	LEPMON	<i>Lepidium montanum</i>
EUPROB	<i>Euphorbia robusta</i>	LEPPER	<i>Lepidium perfoliatum</i>
EURLAN	<i>Eurotia lanata</i> (<i>Ceratoides lanata</i>)	LEPPUH	<i>Leptodactylon pungens</i>
FESCUE (FESTUC)	<i>Festuca</i> spp.	LEPWAT	<i>Leptodactylon watsonii</i>
FESOCT	<i>Festuca octoflora</i>	LITRUD	<i>Lithospermum ruderales</i>
FORMEI	<i>Forsellestia meionandra</i>	LITTER	Litter
GALCOL	<i>Galium coloradense</i>	LOLPER	<i>Lolium perenne</i>
GALIUM	<i>Gallium</i> spp.	MACHAE	<i>Machaeranthera</i> spp.
GILCON	<i>Gilia congesta</i>	MALAFR	<i>Malcomia africana</i>
GILLEP	<i>Gilia leptomeria</i>	MALSON	<i>Malacothrix sanchoides</i>
GILPOL	<i>Gilia polycladon</i>	MELOFF	<i>Melilotis officinalis</i>
GILSIN	<i>Gilia sinuata</i>	MENALB	<i>Mentzelia albicaulis</i>
GILSTE	<i>Gilia stenothyrsa</i>	MENHUM	<i>Mentzelia humilis</i>
		MUHASP	<i>Muhlenbergia asperifolia</i>

TABLE IV-1
BOTANICAL SPECIES
(Cont.)

<u>Six-Letter Plant Code</u>	<u>Scientific Name</u>	<u>Six-Letter Plant Code</u>	<u>Scientific Name</u>
OENCAE	<i>Oenothera caespitosa</i>	SALKAL	<i>Salsola kali</i>
OENDEL	<i>Oenothera deltoides</i>	SARVER	<i>Sarcobatus vermiculatus</i>
OENMIN	<i>Oenothera minor</i>	SCIAME	<i>Scirpus americanus</i>
OENSCA	<i>Oenothera scapoidea</i>	SCIPAL	<i>Scirpus paludosus</i>
OPUNTI	<i>Opuntia</i> spp.	SENECI	<i>Senecio</i> spp.
OPUPOL	<i>Opuntia polycantha</i>	SISALT	<i>Sisymbrium altissimum</i>
OPURHO	<i>Opuntia rhodantha</i>	SISLIN	<i>Sisymbrium linifolium</i>
OROFAS	<i>Orobancha fasciculata</i>	SITHYS	<i>Sitanion hystrix</i>
OROLUD	<i>Orobancha ludoviciana</i>	SPAGRA	<i>Spartina gracilis</i>
ORYHYM	<i>Oryzopsis hymenoides</i>	SPHAER	<i>Sphaeralcea</i> spp.
OXYLIN	<i>Oxybaphus linearis</i>	SPHCOC	<i>Sphaeralcea coccinea</i>
PENFRE	<i>Penstemon fremontii</i>	SPHMUN	<i>Sphaeralcea muiriana</i>
PENSTE	<i>Penstemon</i>	SPHPAR	<i>Sphaeralcea parvifolia</i>
PETPUM	<i>Petradoria pumila</i>	SPOAIR	<i>Sporobolus airoides</i>
PHACEL	<i>Phacelia</i> spp.	SPOCRY	<i>Sporobolus cryptandrus</i>
PHACOR	<i>Phacelia corrugata</i>	STALIT (SSTALI)	Standing dead annuals
PHLHOO	<i>Phlox hoodii</i>	STPAU	<i>Stephanomeria pauciflora</i>
PHLLON	<i>Phlox longifolia</i>	STICOM (STYCOM)	<i>Stipa comata</i>
PHRCOM	<i>Phragmites communis</i>	STRCOR	<i>Streptanthus oordatus</i>
PHYALT	<i>Physocarpus alternans</i>	SUAEDA	<i>Suaeda</i> spp.
PHYAUS	<i>Physaria australis</i>	SUAFRU	<i>Suaeda fruticosa</i>
PHYMON	<i>Physocarpus monogynus</i>	SUANIG	<i>Suaeda nigra</i>
PINEDU	<i>Pinus edulis</i>	SUASUF	<i>Suaeda suffrutescens</i>
PLAPAT	<i>Plantago patagonica</i>	SUATOR	<i>Suaeda torreyana</i>
POAPRA	<i>Poa pratensis</i>	TAMPEN	<i>Tamarix pentandra</i>
POASAN (POASEC)	<i>Poa sanderbergii</i>	TAROFF	<i>Tamaracum officinale</i>
POLTRA	<i>Polanisia trachysperma</i>	TETNUT	<i>Tetradymia nuttallii</i>
POPANG	<i>Populus angustifolia</i>	TETSPI	<i>Tetradymia spinosa</i>
POPFRE	<i>Populus fremontii</i>	TOWINC	<i>Townsendia incana</i>
RANGES	<i>Ranunculus testiculatus</i>	TRADUB	<i>Tragopogon dubius</i>
RHUTRI	<i>Rhus trilobata</i>	UMBELL	<i>Umbelliferae</i>
ROSWOO	<i>Rosa woodsii</i>	VULOCT	<i>Vulpia octoflora</i>
SALEXI	<i>Salix exigua</i>		

TABLE IV-2
SAGEBRUSH/GREASEWOOD VEGETATION CHARACTERISTICS
FALL 1974

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size
AMBPSI	2	26.0	8.4 13.5	4.6	2	30.0	30.0 30.0	-	2	2.0	-0.9 4.9	21.6
ARTNOV	30	28.2	24.5 31.9	7.9	30	684.2	443.4 925.0	55.9	30	3.5	2.5 4.5	36.4
ARTTRI	34	33.2	29.9 36.6	5.6	34	1088.1	876.9 1299.4	20.5	34	4.2	3.6 4.9	13.8
ASTRAG	1	4.0	4.0 4.0	-	1	15.0	15.0 15.0	-	1	3.0	3.0 3.0	-
ATRCON	26	22.1	18.7 25.5	9.1	26	213.9	145.0 282.9	40.2	26	2.4	1.6 3.2	44.9
BARGRO	0	-	- -	-	100	33718.5	32519.5 35147.2	2.0	0	-	- -	-
CHRVIS	21	32.9	29.6 36.2	3.1	22	561.6	368.1 755.1	38.3	21	2.0	1.5 2.5	20.6
CRUCIF	12	28.3	21.6 34.9	9.0	12	12.2	5.3 19.0	52.1	12	1.5	0.9 2.1	26.2
CRYGRM	0	-	- -	-	16	833.1	-263.9 1903.1	374.7	0	-	- -	-
ERIGER	2	6.5	-6.6 19.6	41.5	2	62.0	-107.4 231.4	75.8	2	2.0	-0.9 4.9	21.6
ERIGGO	7	17.0	10.3 23.7	13.1	7	17.9	4.4 31.4	48.3	7	1.7	0.6 2.8	33.0
EURLAN	6	24.0	13.7 34.3	12.8	6	95.0	16.2 173.8	47.3	6	1.0	1.0 1.0	0.0
GRASPI	19	38.1	33.0 43.1	4.8	19	1073.9	627.2 1520.7	47.6	18	1.4	1.1 1.8	12.7
GUTSAR	24	23.0	20.3 25.8	4.9	24	117.8	48.7 186.9	122.0	24	3.5	1.6 5.4	106.3
HILJAM	11	10.0	8.4 11.6	3.6	11	105.0	27.2 182.8	81.1	11	4.6	2.9 6.4	20.6
KOCVES	5	39.4	27.0 51.8	5.3	5	198.0	0.8 395.2	52.9	4	4.3	- 8.5	37.3
LITTER	0	-	- -	-	99	4247.0	3038.3 5455.7	128.3	0	-	- -	-
OPUNTI	6	5.2	4.0 6.3	3.5	7	46.0	15.0 77.0	38.3	6	1.0	1.0 1.0	-
ORYHYM	44	24.9	22.7 27.1	5.4	44	188.5	120.9 256.2	90.6	44	2.7	2.2 3.3	28.2
SALKAL	33	15.8	12.9 18.8	18.6	34	1360.9	907.7 1814.1	60.3	34	114.8	81.0 148.6	47.1
SARVER	31	54.2	46.2 62.2	10.8	37	1366.7	739.3 1994.1	124.8	30	2.4	1.8 3.0	32.4
SITHYS	1	15.0	15.0 15.0	-	1	16.0	16.0 16.0	-	1	1.0	1.0 1.0	-
SPHAER	5	13.6	10.9 16.3	2.1	5	21.0	5.3 36.7	29.9	5	1.4	0.6 2.2	17.7
SPOCRY	1	25.0	25.0 25.0	-	1	155.0	155.0 155.0	-	1	4.0	4.0 4.0	-
STICOM	47	17.6	16.0 19.1	5.6 5.6	47 47	167.9	127.1 208.6	44.3	47	11.5	9.4 13.6	24.8
TETSPI	7	35.9	29.3 42.4	2.8	7	354.3	64.7 643.8	56.4	7	1.3	0.9 1.6	6.2

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

of the ground surface.¹ There was an average of 39 Russian thistle plants and 56 shadscale (*Atriplex confertifolia*) shrubs in each 4-m² plot. Many of the shadscale plants were two- to three-year-old seedlings. Big sagebrush, black sagebrush (*Artemisia nova*), and Indian rice grass (*Oryzopsis hymenoides*) plants occurred about once in each plot, and needle-and-thread grass (*Stipa comata*) occurred about five times in each plot.

Juniper: Fall 1974 juniper data are analyzed on Table IV-3. Juniper (*Juniperus osteosperma*) was the dominant species in height and general appearance in this type, covering about 12% of the area. Approximately 12% of the ground was covered by litter, much of which was under the juniper canopy. Over 85% of the surface was bare ground. Litter and juniper canopy overlapped considerably as surface cover. Galleta-grass (*Hilaria jamesii*) was the other most frequently encountered species, with an average of 9 plants per 4-m² plot. Several other species occurred one to four times in a plot, including black sagebrush.

Shadscale: Fall 1974 shadscale data are analyzed on Table IV-4. In the shadscale type, 90% of the ground surface was bare and litter covered only 1% of the surface. The three principal shrubs--black sagebrush, big sagebrush, and shadscale--covered 7% of the surface, with the rest (3%) covered by less dominant species. An average of 11 halogeton (*Halogeton glomeratus*) plants and 4 Russian thistle plants were encountered in each 4-m² plot.

Riparian: Fall 1974 riparian data are summarized on Table IV-5. In the riparian type, only 21% of the ground was bare, compared with 84% to 90% bare ground in the other types. Litter covered 61% of the surface. Saltcedar (*Tamarix pentandra*) covered 5% of the area, rabbitbrush (*Chrysothamnus* spp.) covered 4%, and greasewood covered 1.5%. Cottonwood trees (*Populus fremontii*) provided an overstory canopy of about 12.5%. In this type, saltgrass (*Distichlis stricta*), equisetum (*Equisetum arvense*), and greasewood were encountered most frequently in the 4-m² plots.

¹The data in the vegetation tables (IV-2 through IV-17) are organized to provide information about individual species parameters on the basis of plots where they were encountered. To determine area-related parameters, the formula (No. Obs. x mean)/100 will give cover or density in terms of the general area, under the assumption that vegetation is seldom disturbed and the 100 plots sampled are representative of the vegetation type.

TABLE IV-3
JUNIPER VEGETATION CHARACTERISTICS
FALL 1974

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individual/4m ²)			
	NUM OBS	MEAN	95% C.I.	Sample Size	NUM OBS	MEAN	95% C.I.	Sample Size	NUM OBS	MEAN	95% C.I.	Sample Size
AGRSMI	3	30.0	6.1 53.9	14.9	3	78.0	-16.6 227.6	80.6	3	6.6	-5.5 18.3	78.2
ARTLUD	28	6.1	5.1 7.0	9.8	28	98.4	54.2 142.2	83.4	25	1.7	1.4 2.1	13.4
ARTNOV	56	11.5	9.6 13.4	24.8	60	763.8	581.4 946.2	54.7	55	3.8	3.1 4.6	32.8
ARTTRI	5	12.8	6.4 19.1	13.0	5	764.2	-427.2 1955.6	129.6	5	3.0	-0.1 6.1	55.3
ASTRAG	20	16.3	13.1 19.5	11.2	20	128.4	75.1 181.6	50.1	20	1.9	1.5 2.2	11.0
ATRCOM	29	12.2	10.0 14.5	14.2	29	225.5	128.9 322.0	79.7	28	2.3	1.7 3.0	32.2
BARGRO	0	-	-	-	100	34278.2	32736.1 25760.3	3.0	0	-	-	-
BOUGRA	1	6.0	6.0 6.0	-	1	130.0	130.0 130.0	-	1	4.0	4.0 4.0	-
CHRGRE	8	10.4	5.4 15.4	12.5	5	50.8	-25.7 127.3	120.8	5	2.2	0.7 3.7	24.1
CHRVIS	29	13.2	10.2 16.3	22.7	29	382.9	271.1 494.8	37.1	29	5.9	4.3 7.4	30.8
CHRGRE	2	14.5	-19.1 48.1	54.5	2	355.0	-623.2 1333.2	77.1	2	2.0	2.0 2.0	-
COMPAL	3	9.3	6.4	2.2	3	21.0	-4.2 46.2	33.7	3	1.3	0.5 2.1	8.1
CRUCIF	21	26.6	20.5 32.8	16.4	21	26.6	16.4 36.9	45.4	21	3.9	-0.1 7.9	319.1
CRYGAM	0	-	-	-	4	1258.8	-269.2 2765.7	56.1	0	-	-	-
DISSTR	11	11.1	9.8 12.4	2.1	11	321.0	-37.4 679.4	184.0	11	21.5	5.2 37.9	84.8
EPHYIR	4	18.3	7.3 29.2	13.8	4	315.0	-108.3 738.3	68.8	4	1.3	0.7 1.8	6.9
ERIGER	40	7.2	5.7 8.7	26.3	40	69.1	50.1 88.1	48.4	40	5.1	2.5 7.7	161.9
ERIOGO	24	8.5	6.8 10.3	14.8	24	35.6	11.8 59.4	157.9	24	2.8	1.5 4.0	72.8
EUPHUR	48	3.5	3.0 4.0	13.1	48	31.4	22.5 40.3	61.2	48	2.6	2.0 3.3	40.9
GUTSAR	55	13.9	12.5	8.0	55	126.7	64.2 189.3	214.4	55	3.7	1.7 5.8	259.1
HALGLO	1	12.0	12.0 12.0	-	1	100.0	100.0 100.0	-	1	20.0	20.0 20.0	-
HILJAM	33	10.5	9.4 11.6	5.7	33	302.7	169.1 436.3	102.8	33	27.9	15.3 40.4	107.4
MYPEND	4	6.8	1.4 12.1	23.7	4	49.8	-10.0 107.5	55.4	4	1.0	1.0 1.0	-
JUNOST	21	158.3	112.5 204.1	25.7	47	9860.4	7202.3 12518.5	54.6	19	1.2	0.9 1.4	8.5
LETTER	0	-	-	-	100	4777.5	3201.1 6353.8	174.2	0	-	-	-
MULASP	1	6.0	6.0 6.0	-	1	130.0	130.0 130.0	-	1	2.0	2.0 2.0	-
OPURIT	2	5.5	1.1 9.9	6.4	2	65.0	-8.0 138.0	12.8	2	1.0	1.0 1.0	-
ORYTHM	54	19.7	17.0 21.5	7.6	54	107.6	46.9 163.3	274.5	54	3.2	2.5 4.0	46.8
PHLPOD	6	4.8	0.8 8.0	47.0	6	15.0	-3.3 33.3	103.0	6	1.0	1.0 1.0	-
POAFEN	1	37.0	37.0	-	1	2.0	2.0 2.0	-	1	1.0	1.0 1.0	-
POASAY	5	15.6	5.6 25.6	22.1	5	40.0	6.9 73.1	36.5	5	2.0	0.9 3.1	16.2
SALKAL	1	6.0	6.0 6.0	-	1	10.0	10.0 10.0	-	1	1.0	1.0 1.0	-
SENECO	2	16.5	12.1 20.9	-	2	275.0	202.0 348.0	-	2	6.5	5.0 8.0	-
SITHYS	3	24.0	14.5 33.5	3.7	3	33.3	25.5 41.2	1.3	3	2.0	0.6 3.4	10.8
SOLRIG	7	18.9	6.6 31.1	35.5	8	63.5	26.0 101.2	34.9	8	2.0	1.2 2.8	15.5
SPHAER	1	10.0	10.0 10.0	-	1	20.0	20.0 20.0	-	1	1.0	1.0 1.0	-
STICOM	1	16.0	18.0 18.0	-	1	40.0	40.0 40.0	-	1	3.0	3.0 3.0	-
TETSPI	1	30.0	30.0 30.0	-	1	150.0	150.0 150.0	-	1	1.0	1.0 1.0	-

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

TABLE IV-4
SHADSCALE VEGETATION CHARACTERISTICS
FALL 1974

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size
AGRSMI	1	26.0	26.0 26.0	-	1	150.0	150.0 150.0	-	1	8.0	8.0 8.0	-
ARTLUD	1	17.0	17.0 17.0	-	1	110.0	110.0 110.0	-	1	1.0	1.0 1.0	-
ARTNOV	27	28.0	24.9 31.1	4.9	28	1559.8	1157.7 1961.0	27.8	27	4.3	3.2 5.4	26.5
ARTTRI	40	27.0	23.3 30.7	11.8	40	2928.8	2086.9 3770.7	52.9	40	3.6	3.0 4.3	20.2
ASTRAG	39	19.6	17.8 20.2	5.2	39	67.1	45.8 89.3	62.7	39	3.6	2.6 4.6	45.5
ATRCON	88	19.0	17.8 21.4	5.4	90	1261.3	1043.5 1479.1	42.9	89	4.9	4.1 5.6	33.5
BARGRO	0	-	-	-	100	36115.9	35623.3 36608.5	1.0	0	-	-	-
CHRVIS	8	31.6	23.9 39.4	6.0	9	542.8	226.2 859.3	39.4	8	1.5	1.0 2.0	11.0
CRUCIF	1	30.0	30.0 30.0	-	1	20.0	20.0 20.0	-	1	1.0	1.0 1.0	-
CRYGRM	0	-	-	-	7	793.6	-35.4 1622.6	92.1	0	-	-	-
ERTIGER	13	10.9	8.7 13.1	7.3	13	158.6	42.0 275.3	97.1	13	4.2	0.9 7.6	112.9
ERIOGO	3	17.7	5.8 29.5	10.6	3	565.0	-429.2 1559.2	72.6	3	10.7	-0.4 21.7	25.2
EUPHUR	2	3.0	-2.8 8.8	38.5	2	26.5	22.1 30.9	-	2	1.0	1.0 1.0	-
EURLAN	4	12.0	8.9 15.1	2.6	4	72.5	18.6 126.4	21.1	4	1.8	0.7 2.8	13.0
GUTSAR	36	17.2	15.1 19.2	8.1	36	154.9	84.6 225.2	118.5	35	6.5	4.2 8.8	70.6
HALGLO	24	4.4	3.6 5.2	11.6	24	108.3	70.6 153.9	42.9	24	45.4	18.9 72.0	121.9
HILJAM	10	12.0	8.1 15.9	14.2	10	407.0	279.5 2534.5	84.7	9	40.3	15.7 65.0	43.2
KOCVES	3	28.0	19.5 36.5	2.2	3	436.7	-120.2 993.5	38.1	3	2.0	0.6 3.4	10.8
LITTER	0	-	-	-	80	351.4	171.9 530.8	333.8	0	-	-	-
OPUNTI	14	5.5	5.1 5.9	1.3	14	179.3	115.9 242.7	24.4	14	2.3	0.7 3.9	97.4
ORYHYM	18	21.6	18.2 24.9	6.3	18	122.1	64.4 179.9	57.9	18	2.8	1.9 3.8	30.6
SALKAL	10	5.2	3.9 6.5	8.1	10	595.4	2.7 1188.0	130.6	10	38.9	9.2 268.6	115.0
SARVER	7	41.3	27.2 55.4	9.9	9	531.8	334.2 2729.3	70.9	7	1.8	1.2 2.5	10.2
SITHYS	1	20.0	20.0 20.0	-	1	20.0	20.0 20.0	-	1	1.0	1.0 1.0	-
SPHAER	5	13.4	9.4 17.4	4.7	5	58.0	25.6 79.5	15.7	5	3.2	0.6 5.7	34.7
STICOM	1	13.0	13.0 13.0	-	1	50.0	50.0 50.0	-	1	1.0	1.0 1.0	-
TETSPI	14	25.6	20.5 30.8	8.0	15	748.1	271.2 1225.1	85.9	13	2.2	1.3 3.1	27.8

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE

TABLE IV-5
RIPARIAN VEGETATION CHARACTERISTICS
FALL 1974

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size
AGRSMT	21	57.1	47.8 66.4	8.2	23	494.6	243.5 745.8	87.4	23	26.7	15.9	54.7
AMBPSI	5	19.4	12.9 25.9	5.9	5	130.0	35.7 224.3	28.0	5	9.0	2.5 15.5	
ANTLUD	1	85.0	85.0 85.0	-	1	5281.0	5281.0 5281.0	-	1	1.0	1.0 1.0	-
ARTTAL	9	71.7	55.8 87.5	5.7	9	2447.8	592.7 4302.8	66.6	9	1.8	1.0 2.6	23.2
ASTRAG	1	30.0	30.0 30.0	-	1	10.0	10.0 10.0	-	1	1.0	1.0 1.0	-
ATRPAT	1	86.0	86.0 86.0	-	1	770.0	770.0 770.0	-	1	1.0	1.0 1.0	-
BARGRO	0	-	-	-	100	8854.2	6807.3 10901.1	85.5	0	-	-	-
CENPAU	0	-	-	-	1	40.0	40.0 40.0	-	1	216.0	216.0 216.0	-
CHRUAU	21	81.5	68.6 94.4	7.7	24	2076.7	531.3 3622.1	196.5	21	1.9	1.3 2.4	26.7
CHRVIS	44	83.7	74.9 92.5	7.8	45	2919.4	1551.1 4177.7	133.8	44	6.1	4.6 7.7	45.7
CIRSIO	0	-	-	-	1	119.0	119.0 119.0	-	1	14.0	14.0 14.0	-
CLELIG	1	24.0	24.0 24.0	-	1	20.0	20.0 20.0	-	1	1.0	1.0 1.0	-
CRYGRM	0	-	-	-	1	1250.0	1250.0 1250.0	-	0	-	-	-
DISSTR	40	19.2	17.3 21.0	5.8	40	1558.2	657.0 2449.4	209.4	39	76.4	46.4 106.2	95.6
EQUARY	6	40.5	22.3 58.7	13.9	6	169.8	-10.6 350.2	77.6	6	271.3	-41.4 584.0	91.4
GUTSAR	3	45.0	22.4 67.6	5.9	3	8433.3	-314.4 17181.0	25.2	3	2.3	0.3 4.4	18.6
IVAAXI	11	19.5	14.6 24.3	9.2	11	103.2	31.3 175.1	71.6	11	9.3	4.0 14.6	48.0
JUNBAL	1	64.0	64.0 64.0	-	1	480.0	480.0 480.0	-	1	464.0	464.0 464.0	-
KOCSCO	4	50.0	5.4 94.6	30.3	4	1077.3	-332.7 2487.2	65.3	4	130.3	-21.2 281.7	51.5
LITTER	0	-	-	-	0	24831.2	22314.3 27348.1	16.3	0	-	-	-
MELOFF	2	28.0	-24.6 80.6	35.8	2	110.0	110.0 110.0	-	2	20.0	14.2 25.8	0.9
MULASP	1	45.0	45.0 45.0	0.0	1	15.0	15.0 15.0	0.0	1	2.0	2.0 2.0	0.0
OPURTI	0	-	-	-	1	50.0	50.0 50.0	-	0	-	-	-
PHRCOM	1	84.0	84.0 84.0	-	1	210.0	210.0 210.0	-	1	1.0	1.0 1.0	-
POAFEN	4	45.8	23.7 67.8	8.8	4	129.5	-13.8 272.8	46.6	4	55.3	-11.9 122.9	56.4
POPFRE	11	2113.1	1055.7 3170.4	37.0	22	23362.7	17642.6 29082.8	19.4	11	2.9	1.1 4.7	56.7
RHUTRI	1	15.0	15.0 15.0	-	1	55.0	55.0 55.0	-	1	3.0	3.0 3.0	-
SALEXI	11	158.8	61.0 256.7	56.0	12	1229.3	360.3 2198.2	101.6	11	2.4	1.2 3.5	33.0
SALKAL	15	18.7	14.0 23.5	13.6	15	887.7	366.2 1409.0	72.9	15	54.9	4.3 105.5	179.8
SARVER	7	421.7	-91.6 935.3	125.0	10	6031.3	2805.2 9257.4	37.7	8	1.6	1.0 2.2	13.8
SISALT	2	63.5	-54.8 181.8	35.2	2	70.0	-105.2 245.2	63.6	2	2.5	1.0 4.0	3.5
SPHAER	2	8.0	-6.6 22.6	33.8	2	12.5	5.2 19.8	3.5	2	2.0	-0.9 4.9	21.6
SPOATR	6	32.0	10.6 53.4	30.6	7	274.3	123.4 425.1	25.5	6	2.3	1.1 3.5	18.0
TAKPEN	13	380.8	119.4 542.2	84.6	18	10596.7	5332.6 15060.8	63.9	14	4.6	2.7 6.5	33.7

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

Spring 1975

Sagebrush-greasewood: Spring 1975 sagebrush-greasewood data are analyzed on Table IV-6. Bare ground in this type accounted for over 87% of the surface. The dominant shrubs--sagebrush, rabbitbrush, and hop sage (*Grayia spinosa*)--each covered 2% of the surface, and greasewood and horsebrush (*Tetradymia spinosa*) each covered 1% of the surface. Cheatgrass made up 4% of the cover, with approximately 1270 plants per 4-m² plot.

Juniper: Spring 1975 juniper data are analyzed on Table IV-7. Juniper trees accounted for 18% of the cover in this type. Bare ground made up 80% of the surface, and litter, under the tree canopy only, covered 5% of the surface. Approximately 7 shadscale plants per plot accounted for less than 1% of the cover.

Shadscale: Spring 1975 shadscale data are analyzed on Table IV-8. Rabbitbrush (*Chrysothamnus greenii*) covered 2% of the surface, and shadscale, big sage, greasewood, and horsebrush (*Tetradymia spinosa*) each provided 1% of the cover in this type. Bare ground accounted for 85% and litter 3% of the surface, in that order. Cheatgrass was nearly 4% of the cover. Some 30 other species made up the rest of the cover in this type, but none individually more than 1%.

Riparian: Spring 1975 riparian data are analyzed on Table IV-9. Cottonwood (*Populus fremontii*) provided 33% canopy cover, and willow (*Salix exigua*) and saltcedar (*Tamarix pentandra*) made up 10% and 5% of the canopy cover, respectively. Less than one greasewood plant per plot provided 14% cover. Cheatgrass was 18% of the surface cover, and bare ground and litter made up 41% and 51% of the surface, respectively.

Fall 1975

Sagebrush-greasewood: Fall 1975 sagebrush-greasewood data are analyzed on Table IV-10. In this type, sagebrush was 6% of the cover and greasewood was 3%. Other shrubs included horsebrush (*Tetradymia nuttallii*), 7% cover, and shadscale, 6%. Bare ground made up 84% of the surface.

Juniper: Fall 1975 juniper data are analyzed on Table IV-11. Juniper trees were 21% of the canopy cover in this type, and bare ground was 82% of the surface cover. Galleta grass made up less than 4% of the cover. All other species provided less than 10% of the cover.

TABLE IV-6
SAGEBRUSH/GREASEWOOD VEGETATION CHARACTERISTICS
SPRING 1975

SPECIES	Height (cm)				Cover (cm ² /4m ²)				Density (Individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
ALLIUM	8	15.25	12.49 18.01	3.3	8	11.38	3.72 19.03	45.3	8	1.50	1.00 2.00	11.0
ARTNOV	77	17.38	15.28 19.47	17.9	82	214.27	179.55 248.99	34.4	1	2.00	2.00	0.0
ARTSPI	16	11.31	8.75 13.88	11.7	17	59.82	40.87 78.78	24.4	1	2.00	2.00	0.0
ARTTRI	175	25.25	24.69 27.81	9.9	105	405.57	405.67 515.48	47.5	5	1.80	0.63 2.97	22.7
ASTRAG	8	5.67	4.71 6.63	2.0	8	45.83	22.38 69.29	18.0	6	1.17	0.84 1.49	5.3
ATACON	79	19.41	16.63 22.18	25.8	83	175.58	128.00 223.15	103.4	7	3.57	1.17 5.98	38.3
BARGRO	0	0.00	0.00 0.00	0.0	113	34551.16	34247.62	1.0	8	0.00	0.00 0.00	0.0
BORAGI	22	10.66	9.29 12.44	6.8	23	1805.09	255.68 3356.49	249.7	23	395.04	134.37 1655.72	244.8
BROTEC	87	20.22	18.33 21.50	5.6	88	1593.05	1067.65 2124.44	156.7	88	1443.73	970.14 1917.31	151.5
CHORNAV	4	37.50	27.29 47.71	2.8	8	837.50	243.38 1431.62	19.2	0	0.00	0.00 0.00	0.0
CHRYTIS	28	25.36	22.59 28.12	5.0	32	236.25	165.37 266.13	22.8	0	0.00	0.00 0.00	0.0
CLELUT	13	25.00	22.54 27.46	1.7	13	141.54	81.35 201.72	32.4	13	16.46	10.58 22.34	22.9
CRUCIF	21	34.17	32.19 42.16	5.5	23	49.30	29.06 69.55	57.1	22	7.91	0.22 15.60	305.7
EUPHOR	5	1.60	0.79 2.41	13.5	5	15.00	9.48 20.52	7.2	5	1.60	0.79 2.41	13.5
EURLAN	8	24.83	18.70 30.97	4.2	8	147.50	69.71 225.29	27.8	0	0.00	0.00 0.00	0.0
FESCUE	5	10.80	6.85 14.75	7.1	5	48.00	17.24 76.16	21.0	5	85.20	-23.81 156.21	86.8
GRASPI	34	32.50	29.51 35.49	4.6	50	813.54	601.07 1026.01	54.6	0	0.00	0.00 0.00	0.0
GUTSAR	49	14.63	13.42 15.85	5.4	53	48.06	38.48 57.63	33.7	12	2.17	1.44 2.82	18.2
HILJAH	21	10.62	9.28 11.95	4.9	21	123.57	74.60 172.54	45.2	21	12.19	6.20 18.18	74.0
KOCANE	16	21.75	15.29 28.21	20.0	17	71.47	51.51 91.43	19.0	13	3.00	2.17 3.83	13.6
LEPHON	13	35.15	28.91 43.39	7.2	13	35.15	16.65 55.65	52.2	12	1.67	1.33 2.00	6.6
LEPRED	10	8.60	5.83 11.37	13.7	10	46.60	14.04 79.16	64.4	10	24.90	7.32 42.48	65.7
LITRAUD	4	6.75	2.73 10.77	13.5	4	100.50	-11.98 212.53	47.7	4	55.50	-2.72 113.72	41.9
LITTER	0	0.00	0.00 0.00	0.0	112	1206.79	430.30 1703.27	741.9	0	0.00	0.00 0.00	0.0
MENALS	12	20.00	18.10 21.90	1.5	12	285.75	93.01 477.89	74.0	12	213.92	27.94 359.89	123.6
OPUNTI	4	8.00	6.26 9.74	1.8	4	218.75	-90.52 523.02	76.1	1	1.00	1.00	0.0
ORYZYM	45	30.62	27.25 32.39	1.9	46	295.11	184.87 401.35	95.4	41	4.60	2.70 6.91	125.2
SALKAL	16	6.75	5.61 7.89	6.5	16	55.63	35.36 71.89	19.4	16	22.00	15.33 28.67	20.9
SARVER	78	47.53	37.21 57.84	58.8	93	550.32	230.80 809.65	521.6	0	0.00	0.00 0.00	0.0
SISLIN	8	42.68	24.15 47.62	2.7	8	20.00	13.19 26.81	11.6	8	5.75	-0.83 12.33	131.2
SITHYS	23	23.48	20.93 26.03	4.0	24	174.90	-43.69 293.61	554.2	18	1.44	1.12 1.76	12.7
SPHCOC	16	20.59	15.59 25.48	13.8	16	85.94	27.55 144.32	104.8	16	1.06	0.95 1.17	2.4
SPIRAL	5	25.00	10.06 39.94	19.0	5	26.00	15.73 36.27	8.3	4	1.00	1.00 1.00	0.0
STICOM	43	39.07	35.30 41.84	3.5	43	566.63	419.47 711.79	47.0	43	14.02	11.23 16.61	27.2
STYCOM	8	28.13	24.22 32.03	1.9	8	95.63	47.50 143.67	25.3	8	4.50	1.82 7.18	35.4
TETSPI	10	32.00	27.91 37.09	3.3	13	510.00	-203.92 1208.62	228.9	0	0.00	0.00 0.00	0.0
UPDELL	3	3.07	2.89 4.45	1.1	3	4.00	2.64 5.35	2.7	3	1.00	1.00 1.00	0.0

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

TABLE IV-7
JUNIPER VEGETATION CHARACTERISTICS
SPRING 1975

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
ARTNOV	196	10.78	10.13 11.43	11.4	219	281.05	242.83 319.27	64.8	9	4.78	1.49 8.06	54.9
ARTTR	0	25.17	18.64 37.69	7.9	8	306.25	36.46 735.64	81.9	0	0.00	0.00 0.00	0.0
ASTRAG	14	6.93	4.03 9.83	34.2	14	28.71	13.85 43.59	52.4	14	1.43	0.80 2.05	38.2
ATRLOH	121	10.35	9.22 11.47	22.8	127	128.56	101.08 156.03	92.8	32	20.88	9.66 32.09	147.8
BARGRO	0	0.00	0.00 0.00	0.0	110	2143.54	15002.36 33924.72	3.7	0	0.00	0.00 0.00	0.0
BORAGE	7	9.71	6.71 12.72	8.1	7	60.86	29.64 92.08	22.2	7	9.57	-3.41 22.56	155.3
BORAGI	48	9.38	7.83 10.92	20.9	48	86.85	60.71 113.00	69.6	48	3.85	1.31 6.40	334.8
BROTEC	18	8.67	7.41 9.92	5.4	18	4.61	2.93 6.29	34.5	18	6.39	1.11 11.67	177.1
CHEALB	8	5.13	3.58 6.67	9.2	8	99.00	29.48 158.52	26.2	8	19.00	9.81 28.19	23.4
CHRGRE	46	14.87	12.73 16.95	14.4	48	288.67	201.17 376.16	70.6	5	2.60	1.46 4.14	12.1
CHRNAU	8	33.75	22.30 45.11	11.3	9	609.44	124.70 1074.19	73.4	0	0.00	0.00 0.00	0.3
CRUCIF	30	19.23	14.83 23.64	23.6	30	22.47	15.35 29.59	45.3	30	3.57	2.29 4.84	57.4
EPHYIR	3	21.00	4.47 37.52	14.5	3	260.00	-33.34 593.34	29.4	0	0.00	0.00 0.00	0.0
ERIGER	3	8.00	3.29 12.71	8.1	3	50.00	-20.59 120.59	46.7	3	3.00	0.28 5.72	19.2
ERTOGO	43	4.51	3.88 5.14	13.3	43	47.72	31.00 64.44	84.4	43	4.19	2.05 6.32	179.4
EUPHOR	34	1.91	1.55 2.28	19.6	34	22.29	16.05 28.53	42.6	34	2.21	1.80 2.61	18.2
FORMEI	3	7.00	3.41 10.59	6.2	3	140.00	57.92 229.08	9.5	0	0.00	0.00 0.00	0.0
GUTSAR	84	12.35	11.28 13.41	10.1	85	49.31	35.27 60.34	68.2	82	3.97	2.94 4.99	34.1
HEOBOR	35	26.69	24.66 28.72	3.2	38	332.87	265.85 419.80	28.8	35	1.57	1.50 2.45	32.4
HILJAM	46	8.59	7.85 9.23	4.9	46	455.11	278.87 631.35	110.4	46	24.72	13.91 35.53	140.7
HYMSCA	9	16.33	13.20 19.46	4.3	0	303.33	127.65 479.02	38.9	9	5.00	2.85 7.14	21.2
JURDST	30	173.67	145.63 201.70	11.8	66	7319.92	5553.42 9081.36	61.1	1	1.00	1.00 1.00	0.0
KOCAME	46	4.85	4.37 5.32	7.0	46	30.02	23.65 36.39	33.1	43	2.47	1.91 3.02	34.4
LEPHON	30	29.40	26.31 32.49	5.0	30	49.43	32.16 66.71	55.1	30	3.03	2.15 3.92	38.4
LEPHAT	4	7.52	-1.49 16.40	53.6	4	105.00	-33.58 243.50	66.4	3	1.67	0.88 2.45	5.2
LITTER	0	0.00	0.00 0.00	0.0	109	1800.46	1271.27 2317.64	143.9	0	0.00	0.00 0.00	0.0
MENALB	3	12.00	2.20 21.80	15.6	3	33.33	0.92 75.74	22.3	3	7.00	-1.15 15.15	31.8
MULASP	4	9.25	4.78 13.72	8.9	4	15.00	15.00 15.00	0.0	4	1.75	0.15 3.35	31.8
ORTHYM	42	23.10	20.49 25.70	8.5	45	205.56	143.32 267.73	66.0	41	3.15	2.58 3.71	21.1
PHACEL	3	8.00	3.10 12.50	8.8	3	16.67	2.53 30.81	16.9	3	12.00	-3.67 27.67	40.0
PHLHOD	20	9.05	6.63 11.47	20.8	20	21.75	12.46 31.04	53.1	20	2.00	1.44 2.56	22.8
POAPAA	20	17.75	14.31 21.19	10.9	21	57.62	15.44 99.23	161.3	20	2.60	1.70 3.50	34.6
SARVER	3	41.00	-20.11 150.11	50.1	4	857.50	-29.63 1744.53	40.8	0	0.00	0.00 0.00	0.0
SISLIN	11	22.15	14.83 30.99	18.4	11	20.82	4.49 37.25	92.0	11	4.45	1.46 7.45	66.9
SITHYS	3	24.67	19.13 30.16	1.2	3	41.67	10.83 63.50	6.4	3	2.33	-0.87 5.47	42.4
SPIMUM	3	20.00	20.00 20.00	0.0	3	37.33	-24.44 69.10	72.3	3	1.00	1.00 1.00	0.0
STICOM	17	35.76	29.70 41.83	7.0	19	572.37	121.84 1011.90	168.9	17	8.00	2.42 13.40	113.9

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

TABLE IV-8
SHADSCALE VEGETATION CHARACTERISTICS
SPRING 1975

Species	Height (cm)				Cover (cm ² /m ²)				Density (Individuals/m ²)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
ALLIUM	9	11.56	7.02 16.09	17.8	11	9.33	1.54 9.12	58.6	9	1.44	1.00 1.69	10.9
ARTSPI	21	7.95	6.65 9.25	8.2	22	122.50	92.06 152.94	19.9	0	0.00	0.00 0.00	0.0
ARTYRI	304	20.80	19.69 21.91	13.9	335	580.66	517.16 644.17	64.1	25	2.24	1.42 3.06	49.8
ASTRAG	15	2.73	1.73 3.74	28.5	15	14.07	6.91 21.22	54.7	15	1.53	1.12 1.95	15.4
ATACOM	504	15.44	14.82 16.07	13.4	539	311.28	285.12 333.44	65.6	60	4.92	3.83 6.04	46.2
BAIMUL	3	8.67	-1.71 19.04	33.6	3	11.67	-9.51 31.75	93.2	3	2.33	0.26 4.41	18.6
BARGRO	0	0.00	0.00 0.00	0.0	107	33638.18	32574.07 34282.78	1.0	0	0.00	0.00 0.00	0.0
BORAGI	21	7.24	5.69 8.78	14.0	21	11.71	8.30 15.13	26.0	21	8.90	4.83 12.98	64.2
BROTEC	69	13.45	12.39 14.51	6.9	69	1504.19	877.39 2169.99	223.5	69	639.97	359.00 920.94	212.8
CHOTEN	7	8.71	5.41 12.02	12.1	7	474.29	143.58 803.00	39.8	7	565.43	-95.60 2026.45	101.9
CHRGAE	6	28.50	19.27 37.73	7.2	11	670.83	235.93 1105.74	26.9	0	0.00	0.00 0.00	0.0
CHRYIS	7	28.14	14.11 42.17	21.0	8	763.25	78.50 1448.00	80.6	2	1.00	1.00 1.00	0.0
CRUCIF	34	23.68	19.71 27.64	15.3	34	46.32	19.62 73.03	180.8	34	3.82	2.69 4.96	48.0
BRIEFF	60	9.57	8.35 10.78	15.5	61	169.84	123.29 216.38	73.3	8	19.50	9.35 29.64	27.1
ERIGER	10	11.30	9.75 12.85	2.5	10	26.10	12.33 39.87	36.7	10	3.00	1.31 4.69	41.7
ERIGOD	40	2.48	1.93 3.02	31.2	40	49.10	18.44 79.76	249.6	34	11.76	8.29 15.24	47.4
EURLAN	11	12.50	8.10 16.90	4.7	4	66.25	18.30 114.20	20.0	0	0.00	0.00 0.00	0.0
GUTSAR	48	11.35	10.13 12.58	8.9	48	95.27	50.55 139.99	169.2	29	7.03	3.88 10.19	87.5
MALGLO	11	1.73	1.30 2.15	9.0	11	64.91	1.76 128.06	139.7	11	13.27	4.51 22.03	64.3
WILJAM	15	9.47	7.59 11.34	8.3	15	109.47	205.66 613.28	52.3	15	9.40	3.68 15.12	78.3
LEPPON	3	33.33	25.03 41.63	1.5	3	38.33	-34.30 110.95	84.2	3	1.33	0.55 2.12	8.1
LEPRED	19	6.37	5.50 7.24	5.1	19	23.11	7.73 38.49	121.9	18	33.63	9.99 57.29	136.1
LITTER	0	0.00	0.00 0.00	0.0	108	1216.71	976.07 1457.36	67.6	0	0.00	0.00 0.00	-0.0
RENALB	11	12.22	8.16 15.89	10.4	9	33.67	5.54 61.60	81.0	8	13.67	4.01 23.32	57.9
OENCAE	11	2.67	1.47 3.86	13.8	6	65.67	9.59 123.74	59.4	6	1.67	1.26 2.08	4.2
OPUNTI	28	7.71	7.00 8.42	3.5	28	177.61	69.33 304.63	215.1	19	2.00	0.71 3.29	114.2
ORTHYM	33	19.27	16.77 21.78	8.9	33	53.58	36.46 70.69	53.9	33	3.27	2.51 4.04	28.9
SALCAL	13	3.00	2.78 3.72	10.4	13	24.69	5.04 44.34	113.6	13	11.54	6.68 16.40	31.8
SARVER	10	23.00	16.64 29.36	10.1	11	312.73	116.39 569.07	64.1	1	1.00	1.00 1.00	0.0
SISLIN	3	25.33	8.43 44.06	10.6	11	12.33	-3.53 28.20	30.8	3	7.33	0.91 13.75	18.0
WITHTH	3	29.00	25.65 31.35	0.2	3	5.00	5.00 5.00	0.0	3	1.33	0.55 2.12	8.1
SITHYS	29	20.62	19.45 22.70	4.8	29	108.45	-37.87 293.76	700.8	28	2.79	1.91 3.67	43.3
SPHOCOC	21	10.67	7.1 13.42	20.4	21	38.67	19.39 57.94	76.3	21	1.48	1.17 1.78	13.1
SPOAIR	5	14.20	10.70 18.30	4.4	5	149.00	23.45 274.45	37.8	5	1.60	0.79 2.41	13.5
STICOM	3	28.67	21.70 35.64	1.4	3	128.33	-19.51 276.58	31.3	3	6.00	2.41 9.59	8.4
SUADIA	5	20.70	15.91 24.59	2.5	5	85.00	56.83 119.17	8.6	0	0.00	0.00 0.00	0.0
SUATOR	5	24.60	13.61 35.59	10.9	5	172.00	11.01 232.99	44.1	1	5.00	5.00 5.00	0.0
TETSPI	56	23.98	21.10 26.78	12.2	61	403.46	278.94 547.94	114.9	3	1.67	0.10 3.24	20.8
UPIDELL	3	2.67	0.53 4.74	14.2	3	10.67	-1.45 22.77	30.9	3	2.00	-0.35 4.35	32.5

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

TABLE IV-9
RIPARIAN VEGETATION CHARACTERISTICS
SPRING 1975

Species	Height (cm)				Cover (cm ² /4m ²)				Density (Individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
WGRSEP	3	56.33	17.31 95.36	11.3	3	169.33	-172.10 500.77	89.9	3	7.33	3.18 11.48	7.5
WGRSHE	41	42.93	39.14 46.71	5.1	41	297.44	230.51 364.37	33.2	41	10.46	11.11 25.82	104.1
WGRSSE	6	6.00	5.45 11.30	7.4	8	400.00	83.52 836.40	57.0	8	57.00	15.49 119.06	58.9
WRTTRI	34	34.50	28.49 40.51	16.5	38	66.84	301.72 1031.96	182.3	5	7.00	-4.11 18.11	134.3
WIRCAN	7	49.43	35.93 62.93	6.3	8	578.75	210.40 917.10	40.5	0	0.00	0.00 0.00	0.0
WTRPAT	42	13.90	12.01 15.80	12.4	42	141.02	82.79 195.25	114.6	42	16.17	9.47 22.86	115.2
WARGRO	0	0.00	0.00 0.00	0.0	60	16623.25	13622.25 15424.25	27.3	0	0.00	0.00 0.00	0.0
WASHYS	7	8.14	5.94 10.35	6.2	7	102.65	51.21 154.50	21.3	7	57.71	0.71 114.71	82.3
WORAGI	11	11.00	8.06 13.94	10.5	11	54.45	20.87 83.04	56.1	11	55.45	-1.57 112.48	156.1
WROTEC	92	36.58	30.62 42.53	39.0	92	7221.75	5619.06 8824.44	72.5	92	1909.53	1471.10 2347.96	77.6
WELSAN	8	21.75	18.35 25.15	2.5	8	223.75	117.25 330.25	22.7	8	67.88	-5.65 141.44	117.6
WCHVIS	4	63.00	37.48 88.52	6.3	4	1327.50	-1076.49 3731.49	124.9	4	4.00	0.86 7.14	23.4
WCHTER	11	12.27	8.82 15.72	11.7	11	111.82	47.57 176.06	48.7	11	217.55	25.34 409.75	115.2
WCHRGE	4	39.00	23.76 54.74	6.2	4	930.00	274.37 1585.63	18.9	0	0.00	0.00 0.00	0.0
WCHRAU	25	46.36	33.85 58.87	27.0	29	1004.14	133.63 1874.65	326.8	12	2.58	0.92 -4.25	67.8
WCHRAY	3	72.33	17.78 126.88	13.3	3	346.57	-197.64 850.97	57.8	3	1.00	1.00 1.00	0.0
WCHRYIS	38	53.82	49.62 68.01	14.9	41	767.49	579.15 955.02	39.5	32	4.56	3.35 5.78	36.2
WCLELUT	4	37.50	19.29 55.71	9.0	4	665.00	-1.77 1331.77	38.3	4	11.25	-0.47 22.97	41.4
WCRUCIF	51	33.41	29.58 37.25	10.7	51	120.86	70.48 171.25	141.8	51	24.76	14.54 34.98	139.0
WDISSPI	19	19.47	16.84 22.10	5.0	19	1015.16	215.96 1814.36	170.5	19	88.00	42.54 133.46	73.4
WDISSTRA	16	17.19	14.47 19.91	5.7	17	706.76	454.46 949.06	28.6	17	81.29	53.24 115.35	33.0
WEQUARY	4	29.75	26.34 33.16	0.5	4	110.50	-35.10 256.10	66.1	4	98.50	-40.52 237.52	75.9
WFESOCY	7	12.86	7.30 18.41	15.7	7	39.57	15.16 63.90	32.1	7	35.71	7.76 63.67	51.7
WYAAKI	22	16.86	14.78 18.95	4.9	22	278.09	110.22 445.96	117.7	22	43.05	22.39 63.70	74.4
WJUGIAL	5	54.40	45.65 63.15	1.4	5	14.60	-3.64 32.84	83.2	5	4.60	1.57 7.63	23.1
WKICHIA	9	10.89	8.57 13.20	5.2	9	1327.22	-113.07 2767.52	136.5	9	305.11	-88.00 698.22	192.5
WLEPIDI	7	13.14	8.76 17.53	9.4	7	719.43	-105.44 1805.30	127.9	7	72.86	-1.53 147.30	80.1
WLEPPER	14	19.93	15.42 24.44	10.0	14	249.21	1.22 477.21	193.5	14	349.14	-106.16 804.45	332.3
WLEPROD	18	22.84	17.57 28.11	14.7	18	23.68	5.67 41.70	159.1	19	27.53	11.29 43.77	95.8
WLITTER	0	0.00	0.00 0.00	0.0	108	20604.68	18181.41 22725.94	18.3	0	0.00	0.00 0.00	0.0
WMELOFF	37	16.05	11.47 20.64	48.3	38	1194.87	581.32 1408.42	160.3	37	89.08	42.03 136.08	164.8
WPOAPRA	14	64.43	55.53 73.33	3.7	14	1150.71	270.92 2074.51	125.9	14	44.86	18.27 71.44	68.6
WPOPFRE	11	926.82	254.27 1519.37	77.7	30	3302.33	8171.76 12740.51	50.8	6	2.50	0.64 4.35	38.1
WSALEBI	13	152.31	108.32 196.30	15.0	17	4088.94	1442.86 6695.02	98.7	12	3.75	2.15 5.35	29.7
WSALKAL	13	10.23	7.32 13.14	14.6	13	149.62	35.01 261.22	105.3	13	34.82	-1.19 71.12	199.5
WSARVER	11	77.45	50.84 104.07	17.4	12	5623.33	654.03 10772.50	127.7	2	3.00	1.00 1.00	0.0
WSPDAIR	5	19.20	11.45 26.72	8.2	5	670.00	293.43 1034.57	74.3	5	5.00	-2.57 12.57	122.1
WTAMPER	13	217.62	167.53 265.70	8.8	17	2470.40	1625.73 3315.94	80.7	11	6.00	2.43 9.57	52.2
WTANOFF	10	22.40	12.47 32.33	25.9	10	106.00	55.09 156.20	29.6	10	4.80	1.42 8.18	65.5
WTRADIB	6	37.33	21.74 44.93	12.8	6	18.17	-9.74 46.17	162.9	6	2.50	0.44 4.36	10.1

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

TABLE IV-10
SAGEBRUSH/GREASEWOOD VEGETATION CHARACTERISTICS
FALL 1975

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size
ARTFRI	1	43.0	-	-	1	600.0	-	-	1	1.0	-	-
ARTSPI	13	9.8	11.9 7.7	11.7	7	249.3	352.8 145.8	20.6	7	2.4	4.5 0.3	89.0
ARTTRI	136	29.2	31.1 27.3	12.9	64	2395.9	2050.8 1941.1	52.4	64	5.1	6.5 3.8	99.0
ASTRAG	1	4.0	-	-	1	25.0	-	-	1	1.0	-	-
ATRARG	-	-	-	-	1	75.0	-	-	1	14.0	-	-
ATRCON	399	24.6	32.8 16.4	1008.0	94	2241.7	2524.7 1958.7	34.0	94	8.8	10.3 7.3	63.1
ATRPOM	-	-	-	-	1	30.0	-	-	1	1.0	-	-
BARGRO	20	1.0	-	-	100	3303.9	34139.0 33118.7	1.0	100	1.0	1.0 1.0	-
CHRGRE	21	26.5	28.7 24.3	3.0	13	859.2	1420.7 311.6	104.8	13	2.2	3.2 1.2	44.9
ERIEFF	38	23.1	25.6 20.6	15.9	15	400.0	648.4 151.6	115.7	15	6.9	9.1 4.8	28.4
ERIENG	22	16.1	19.2 3.3	16.3	24	330.1	39.7 20.5	51.1	24	4.9	6.5 3.2	57.6
ERIOGO	3	16.3	29.4 3.3	21.3	3	15.0	21.8 8.2	6.8	3	11.7	30.9 -7.6	90.5
EURLAN	8	11.5	14.4 8.6	9.0	6	78.3	126.9 39.8	37.5	6	1.8	2.8 0.9	25.0
GRASPI	2	43.5	-	-	3	865.7	-	-	3	1.0	-	-
GUTSAR	36	19.7	21.4 18.0	6.1	37	238.4	458.6 18.1	717.8	37	7.5	10.3 4.6	123.2
HALGLO	0	-	-	-	5	400.0	1206.0 -406.0	308.3	5	42.4	82.1 2.7	66.3
HILJAM	9	23.7	33.7 13.6	29.5	9	675.0	1079.3 270.7	59.1	9	10.9	16.0 5.8	36.1
OPURTI	20	7.6	8.6 6.6	7.2	13	282.3	435.2 129.4	74.7	13	1.6	2.2 1.1	29.6
OPUSPP	3	5.7	9.8 1.5	17.9	1	525.0	-	-	1	3.0	-	-
ORYHYM	28	20.6	21.4 18.2	9.2	28	279.8	671.9 -112.4	1168.8	28	5.9	11.3 0.6	458.4
SALKAL	-	-	-	-	5	-	-	-	5	15.8	24.0 7.6	20.4
SARVER	22	33.1	40.6 25.6	23.5	13	1286.4	1890.1 602.7	56.1	13	1.9	2.4 1.4	17.9
SITHYS	2	21.0	-	-	2	70.0	-	-	2	3.0	-	-
SPHCOC	14	18.1	21.9 14.4	12.0	14	47.7	68.4 27.0	52.4	14	2.8	3.9 1.7	46.5
SPHPAR	2	21.5	-	-	2	20.0	-	-	2	1.5	-	-
SPOAIR	2	7.0	-	-	2	825.0	-	-	2	7.5	-	-
STICOM	10	46.9	55.0 38.8	5.6	10	139.5	263.9 15.1	149.8	10	2.2	3.0 1.5	22.0
SUASUE	5	31.6	43.0 20.3	9.7	5	180.0	333.4 -33.4	106.4	5	1.6	2.4 0.8	19.2
TETNUT	6	35.0	45.8 24.3	9.2	2	2907.5	-	-	2	4.0	-	-
TETSPI	20	33.3	35.4 20.3	9.5	15	990.7	1575.2 406.1	104.5	15	2.0	2.7 1.3	32.9

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

TABLE IV-11
JUNIPER VEGETATION CHARACTERISTICS
FALL 1975

Species	Height (cm)				Cover (cm ² /4-m ²)				Density (individual/4-m ²)			
	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size
ARTROV	116	17.4	19.1 15.8	16.7	42	352.1	1103.2 600.9	58.4	42	4.7	5.8 3.7	32.9
AKTR1	30	25.2	30.0 20.3	16.9	18	618.8	915.8 321.9	59.7	18	2.0	2.5 1.5	17.8
ASTRA	5	24.0	23.7	8.8	6	326.0	555.4 52.5	40.4	6	1.3	1.7 .9	6.5
ATRCOM	27	18.1	22.6 13.7	23.9	19	282.4	407.0 157.8	53.6	19	1.9	2.6 1.2	38.7
BARGRO	0	-	-	-	100	32799.7	34495.0 21103.0	4.3	0	-	-	-
BOUGRA	1	30.0	-	-	1	25.0	-	-	1	1.0	-	-
CHRGRE	8	19.4	25.4 13.4	9.7	6	195.0	455.4 -65.4	122.7	6	1.8	2.9 .8	22.8
CHRVIS	11	24.0	30.1 17.9	9.4	9	801.1	1244.0 357.0	35.5	9	1.3	1.6 1.0	6.1
CRUCIF	6	9.0	16.4 1.6	46.4	6	5.2	7.6 2.7	15.2	6	1.3	1.9 .7	16.2
CRYPTA	33	9.4	11.2 7.5	-	33	82.2	98.9 65.6	-	33	2.7	3.4 2.0	-
EPHVIR	5	18.4	24.8 12.0	6.4	5	146.0	276.8 15.1	43.0	5	1.2	1.6 .8	6.0
ERIGER	7	21.7	30.9 12.5	15.2	7	49.3	75.3 23.1	23.8	7	1.7	2.2 1.2	8.4
ERIMIC	22	13.9	15.7 12.1	5.4	23	68.8	111.7 25.9	131.7	23	2.0	2.7 1.5	28.8
ERIOGO	9	13.1	16.3 9.8	7.3	10	33.0	46.2 19.7	21.2	10	2.8	3.7 1.9	13.3
ERIOVA	10	4.2	5.1 3.3	6.4	10	25.4	36.2 14.6	24.0	10	3.9	6.6 1.1	65.4
EUPFEN	22	4.3	5.0	8.3	22	56.4	73.8 33.9	31.0	22	1.8	2.2 1.4	13.3
EUPROF	7	5.4	7.5 3.3	12.7	7	69.8	99.5 40.2	15.2	7	2.1	2.9 1.4	10.8
GRASPI	0	-	-	-	1	300.0	-	-	1	1.0	-	-
GUTSAR	52	17.3	18.8 15.7	6.6	51	61.4	73.7 49.0	33.0	51	2.3	3.2 1.9	53.0
HALGLO	1	4.0	-	-	2	201.0	782.0	84.0	2	1.0	-	-
HEGBOR	5	24.2	28.9 19.5	2.0	5	420.0	721.0 118.0	27.0	5	2.2	3.3 1.0	15.8
HILJAM	12	12.5	15.9 9.2	11.5	12	1243.0	2679.0 193.0	218.0	12	20.6	31.0 10.3	41.0
JUNDST	21	171.4	214.1 128.5	18.0	55	8569.3	11026.0 5052.0	77.0	56	1.1	1.1 1.0	4.3
KOCAME	1	15.0	-	-	1	150.0	-	-	1	1.0	-	-
LEPPUN	3	4.3	5.9 2.8	3.1	3	18.3	28.7 7.9	7.0	3	2.3	3.1 1.5	2.7
LITTER	0	-	-	-	58	546.0	800.4 292.6	-	58	-	-	-
OPUPOL	1	8.0	-	-	1	200.0	-	-	1	2.0	-	-
ORYTHM	17	25.1	31.0 19.2	13.0	18	92.0	137.5 46.5	63.0	18	5.6	10.2 1.0	17.4
PETPUR	19	14.7	17.4 11.9	9.0	16	197.2	311.5 83.0	76.0	16	4.0	6.1 1.9	62.0
PHLHOO	13	4.9	6.3 3.5	14.0	13	93.7	157.2 30.3	82.0	13	2.5	3.4 1.6	23.0
PINECU	1	40.0	-	-	1	100.0	-	-	1	1.0	1.0 1.0	-
POASEC	6	36.6	46.9 26.4	5.4	6	570.0	897.0 244.0	22.5	6	19.2	13.5 4.7	16.0
RANTES	2	8.5	15.8 1.2	7.5	2	17.5	39.4 -4.4	15.0	2	1.0	1.0 1.0	-
SITHYS	2	21.0	32.6 9.3	3.0	2	35.0	78.8 -8.8	15.9	2	2.5	6.8 1.8	31.2
STALIT	0	-	-	-	68	1560.0	2212.0 908.0	189.0	68	-	-	-
STICOM	20	21.6	25.9 17.3	11.0	20	42.6	60.9 24.2	54.0	20	1.7	2.1 1.3	16.0

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

Shadscale: Fall 1975 shadscale data are analyzed on Table IV-12. In the fall the cover of standing dead annuals was measured. Collectively, this cover accounted for 18% of the surface. Sagebrush (*Artemisia tridentata*) and *A. nova* were 11% of the cover, rabbitbrush was 13%, and hop sage (*Grayia spinosa*) and greasewood were each 6%. Shadscale was less than 2% of the cover.

Riparian: Fall 1975 riparian data are analyzed on Table IV-13. Cover in the riparian overstory was 50% cottonwood. The shrub cover was 11% willow, 11% saltcedar, and 10% rabbitbrush; none of the other shrubs contributed over 5%. Some of the dominant grasses were Kentucky bluegrass (*Poa pratensis*) with 7% cover and *Muhlyenbergia asperifolia* with 26%. Most of the cover was standing dead annuals, at 70%.

Spring 1976

Sagebrush-greasewood: Spring 1976 sagebrush-greasewood data are analyzed on Table IV-14. Greasewood and sagebrush were 3% and 5% of the cover, respectively. Hop sage was 4% of the cover and rabbitbrush was 3%. In this type, bare ground was 78% of the surface and litter was 11%. The dominant annuals were Russian thistle, 5% of the cover, and cheatgrass, 3%.

Juniper: Spring 1976 juniper data are analyzed on Table IV-15. Juniper made up 38% of the overstory, and pinon pine (*Pinus edulis*) contributed 8%. On the surface, litter was 8% of the cover and bare ground was 86%. Indian ricegrass (*Oryzopsis hymenoides*), the most frequently observed grass, was only 0.7% of the cover.

Shadscale: Spring 1976 shadscale data are analyzed on Table IV-16. The shadscale type studied in the spring of 1976 was 94% of the bare ground and nearly 3% of the litter on the surface. Sagebrush made up only 5% of the shrub cover and rabbitbrush, 2%. The only other shrub contributing any cover was horsebrush, at 2%. Annuals and grasses were negligible.

Riparian: Spring 1976 riparian data are analyzed on Table IV-17. Cottonwood made up 46% of the overstory in this type and saltcedar, 8%. On the surface, litter accounted for 77% of the cover and bare ground, only 20%. Sagebrush and rabbitbrush were 7% and 9% of the cover as shrubs, and greasewood made up 10%. Cheatgrass was 4% of the cover, as the most important grass species.

TABLE IV-12
SHADSCALE VEGETATION CHARACTERISTICS
FALL 1975

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size
AMBPSI	1	47.0	-	-	1	100.0	-	-	1	1.0	-	-
ARTNOV	81	16.5	16.1 14.9	17.9	22	1697.7	2485.7 909.7	69.6	22	4.6	5.6 3.7	13.0
ARTSPI	22	8.5	9.7 7.2	6.8	5	985.0	2127.6 -157.6	71.7	5	6.6	15.0 -1.8	86.3
ATRTRI	160	22.2	31.1 27.3	10.0	47	2773.9	3324.6 2223.4	29.6	47	4.9	5.8 4.1	23.2
ASTRAG	4	5.5	9.1 1.9	15.7	5	30.4	66.1 -5.3	73.6	5	4.2	7.4 .9	31.2
ATRCOR	46	18.9	20.9 16.9	8.4	26	509.0	640.7 378.8	25.7	26	2.2	2.7 1.7	21.8
BARGRO	-	-	-	-	99	22715.5	29046.9 26394.1	3.7	99	1.0	1.0 1.0	-
CHRGRE	56	32.3	34.8 29.7	5.5	28	1266.4	1672.5 860.3	57.5	28	3.2	4.4 2.1	54.2
CHRNAU	2	56.0	-	-	2	4000.0	-	-	2	1.0	-	-
EPHVIR	1	25.0	-	-	2	150.0	-	-	2	1.0	-	-
ERIENG	6	20.0	24.2 15.8	4.1	6	43.3	76.4 10.2	40.0	6	1.2	1.4 .8	5.0
ERIOGO	12	17.3	19.6 15.0	4.1	13	93.5	130.7 56.2	40.4	13	1.6	2.1 1.1	25.7
EURLAN	8	22.5	30.0 14.9	11.3	7	276.4	452.1 100.8	34.1	7	1.3	1.8 .7	15.0
GRASPI	60	35.0	37.4 32.5	4.7	29	2360.7	3029.4 1692.0	33.6	29	2.3	2.7 1.7	26.3
GUTSAR	14	19.9	22.8 17.0	4.2	14	293.9	450.1	55.2	14	4.9	7.8 2.0	68.1
HILJAM	10	22.4	27.3 17.4	6.3	10	464.0	676.1 251.9	27.5	10	8.5	10.8 6.1	10.3
HYMENO	1	5.0	-	-	2	75.0	-	-	2	2.0	-	-
LEPHON	3	43.3	53.7 32.9	1.3	3	500.0	500.0 500.0	-	3	3.6	4.4 2.9	1.1
OPUNTI	2	6.5	16.7 -3.7	25.1	2	110.0	-	-	2	1.0	-	-
ORYHYM	50	45.4	48.3 42.6	3.1	49	668.6	812.7 524.3	36.5	49	105.8	373.1 -61.8	1968.1
SARVER	60	49.1	55.2 42.7	15.1	40	2475.6	3288.8 1662.5	69.1	40	2.1	2.6 1.5	44.1
SITHYS	6	23.2	29.2 17.1	4.7	5	155.0	272.3 37.5	30.6	5	1.2	1.6 .8	6.0
SPIICOC	4	20.0	31.7 8.2	8.1	4	185.0	555.9 -185.1	34.3	4	2.0	4.3 -3	32.5
SPOCRY	3	28.3	36.2 20.5	1.8	3	158.3	325.8 -9.2	26.3	3	1.7	3.2 .1	20.8
STALIT	-	-	-	-	99	7381.6	8636.1 5805.1	65.1	99	1.0	-	-
STICOM	39	60.5	64.5 56.7	2.6	39	976.9	1249.4 304.7	47.2	39	13.6	16.9 10.3	35.9
SUAEDA	6	45.1	57.3 32.7	5.1	3	341.7	427.1 256.2	1.5	3	2.0	3.4 .0	10.8
YETSPI	6	34.6	42.6 26.7	3.6	6	708.3	1153.8 262.8	27.2	6	1.0	1.0 1.0	-

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

TABLE IV-13
RIPARIAN VEGETATION CHARACTERISTICS
FALL 1975

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individuals/4m ²)			
	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size	NUM OBS	MEAN	90% C.I.	Sample Size
ACRSH1	24	76.4	66.4 86.4	6.1	24	1033.7	1748.7 110.8	270.0	24	13.8	23.5 4.2	172.0
AMPST	5	36.4	78.1 -6.1	72.1	5	190.1	477.1 -96.3	120.0	5	9.2	20.9 -2.5	85.1
AATLUO	1	47.1	-	-	1	350.0	-	-	1	1.0	-	-
ARILKI	6	54.3	80.1 20.5	26.6	6	690.0	1479.9 300.1	30.4	6	3.5	6.5 .4	53.4
ATRCAN	2	37.1	121.6 -47.7	53.1	3	1351.7	3749.1 1016.0	73.1	3	1.0	1.0 1.0	-
ATRCOH	1	85.1	-	-	1	120.0	-	-	1	-	-	-
ATRPA1	21	39.7	50.5 28.9	22.1	21	170.5	271.1 119.1	27.1	21	9.5	14.7 4.3	90.0
ATRFOW	1	28.1	-	-	1	100.1	-	-	1	1.0	-	-
BARGRO	-	-	-	-	100	6537.5	8374.1 4700.0	-	100	1.0	-	-
CHRYAU	24	84.4	94.8 74.1	5.3	27	2203.2	3600.7 777.8	175.7	27	1.6	2.1 1.3	16.8
CHRYTS	45	87.2	99.1 75.2	13.4	46	2277.8	2013.0 1541.0	76.8	46	5.9	7.4 4.5	42.3
CIRSTU	3	6.0	34.6 5.4	5.4	3	425.0	498.0 352.0	-	3	6.5	7.9 5.0	-
CLELIG	2	15.0	-	-	2	310.0	-	-	2	1.0	-	-
CLESER	2	50.0	-	-	2	200.0	-	-	2	2.5	-	-
CONPAL	11	25.2	30.4 19.9	6.4	11	727.7	1219.0 236.0	67.3	11	32.3	47.0 17.0	31.2
DESSUP	1	22.0	-	-	1	5600.0	-	-	1	1.0	-	-
DIFFDT	1	27.0	-	-	1	1000.0	-	-	1	-	-	-
DISSPI	49	23.4	25.4 21.5	5.5	48	1405.0	1843.0 967.0	74.6	48	53.4	68.1 38.6	58.4
EQUATV	6	48.8	70.8 26.8	13.9	6	2929.0	6590.0 -731.0	107.0	6	324.8	528.7 66.9	43.0
GRISQU	1	37.0	-	-	3	35.0	68.9 1.0	49.0	3	3.0	7.7 -1.7	128.0
GUISAR	1	37.0	-	-	1	20.0	-	-	1	1.0	-	-
JURBAL	6	52.6	81.7 23.4	16.4	5	176.0	313.8 38.2	32.7	5	74.4	137.3 11.5	38.1
KELOFF	25	17.5	21.4 13.7	25.6	25	629.9	863.8 391.0	75.7	25	56.6	85.5 27.8	136.0
PHRASP	2	54.0	-	-	2	0500.0	-	-	2	178.0	-	-
OPUNTI	1	6.0	-	-	1	30.0	-	-	1	1.0	-	-
PHRCOH	3	153.3	202.4 24.2	16.6	3	969.0	2072.0 -152.0	31.5	3	44.3	103.5 -14.8	41.0
POAPRA	5	45.25	83.4 7.1	27.1	5	2925.0	5690.4 151.5	34.2	5	94.0	159.6 38.4	18.0
POPTRE	14	1300.4	1825.7 775.1	31.9	31	20098.0	35076.0 15961.0	27.7	31	2.5	3.4 1.7	56.9
SHUTRE	1	13.0	-	-	1	15.0	-	-	1	2.0	-	-
ROSMOO	1	32.0	-	-	1	350.0	-	-	1	2.0	-	-
SALEX1	12	280.7	464.9 96.4	70.5	13	4725.4	8056.7 1394.5	89.1	13	2.5	3.2 1.7	16.2
SALKAL	16	32.3	39.8 26.0	9.2	16	920.2	1460.2 300.2	76.2	16	40.9	77.2 26.6	25.8
SARVER	9	103.4	143.3 63.6	30.0	12	7097.0	1229.5 1719.0	206.0	12	1.7	2.5 .7	109.0
SENECT	1	98.0	-	-	1	950.0	-	-	1	17.0	-	-
SPOAIR	3	42.0	67.1 12.8	10.8	3	1350.0	3539.0 -833.0	61.7	3	1.7	3.2 .1	20.1
STALIT	0	-	-	-	1	16000.0	-	-	1	1.0	-	-
STALIT	0	-	-	-	89	27661.0	27666.0 27666.0	8.3	89	1.0	-	-
TAMPER	10	306.7	464.8 148.6	77.8	13	4469.0	6101.0 2611.0	65.3	13	2.3	3.5 1.1	115.4
TARCH F	1	6.0	-	-	1	1399.0	-	-	1	-	-	-

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

TABLE IV-14
SAGEBRUSH/GREASEWOOD VEGETATION CHARACTERISTICS
SPRING 1976

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
AGRINE	-	-	-	-	1	14.0	-	-	1	1.0	-	-
ALLIUM	2	12.5	19.8 5.2	3.5	2	20.0	34.6 5.4	5.4	2	3.0	3.0	-
ARTEMI	-	-	-	-	1	11.0	-	-	1	4.0	-	-
ARTFRI	3	12.3	23.4 1.3	18.9	3	156.7	409.9 -96.6	61.3	3	2.7	6.6 -1.3	50.7
ARTNOV	11	11.8	13.6 10.0	3.3	11	497.7	620.7 374.8	9.0	11	3.6	5.0 2.1	25.0
ARTNOVSD	2	3.5	10.8 -3.8	44.2	6	155.5	331.4 -20.4	88.0	6	4.1	3.9 1.4	30.3
ARTSPI	8	11.9	14.4 9.3	4.5	10	403.0	610.6 196.4	35.0	10	5.0	9.2 .8	93.9
ARTTRI	119	36.7	38.7 34.8	5.5	123	2088.2	2335.3 1841.1	27.6	123	3.3	3.6 3.0	19.6
ARTTRISD	-	-	-	-	7	78.4	180.9 -24.1	144.2	7	1.7	2.4 1.0	13.3
ASTCHI	6	15.5	22.7 8.3	15.0	6	30.3	67.6 -6.9	103.7	6	1.0	1.0 1.0	-
ASTDIV	3	31.0	53.9 8.2	12.7	3	21.7	35.8 7.5	10.0	3	1.3	2.1 0.6	8.1
ASTRAG	20	9.5	14.3 4.7	73.5	20	75.1	126.4 23.8	135.6	20	2.2	2.7 1.7	17.5
ATRCAN	1	41.0	-	-	1	250.0	-	-	1	1.0	-	-
ATRCON	42	19.8	21.9 17.8	7.4	44	357.1	427.6 286.5	27.5	44	2.0	2.4 1.5	37.9
ATRCONSD	-	-	-	-	5	44.0	72.7 15.3	22.7	5	1.6	2.1 1.1	5.1
ATRIPL	1	11.0	-	-	1	15.0	-	-	1	3.0	-	-
BARGRO	-	-	-	-	199	31388.2	32247.1 30529.3	2.4	199	1.0	1.0 1.0	-
BORAGI	4	2.5	3.6 1.4	6.9	4	12.5	19.3 5.7	11.4	4	5.8	11.8 -0.3	42.2
BROTEC	134	14.2	14.7 13.7	2.7	134	1059.9	1478.8 641.1	334.8	134	688.8	830.9 546.6	91.3
CASSCA	1	25.0	-	-	1	15.0	-	-	1	1.0	-	-
CERLAN	5	20.8	28.5 13.1	7.4	5	267.0	500.2 33.8	40.6	5	3.0	5.6 0.5	38.5
CHADOU	8	6.4	9.9 2.8	31.0	8	18.0	31.5 4.5	56.3	8	4.3	9.5 -1.0	155.3
CHRGRE	5	28.0	38.4 17.6	7.3	6	1270.0	2290.9 249.1	44.5	6	2.8	4.5 1.1	24.6
CHRNAU	9	44.1	56.4 31.9	8.9	12	636.3	1021.1 251.4	59.8	12	1.2	1.4 1.0	4.8
CHRVIS	34	34.3	37.3 31.3	4.2	38	893.8	1112.9 674.7	36.5	38	2.7	3.3 2.2	24.9
CHRVISSD	1	2.0	-	-	3	13.3	27.2 -0.5	25.4	3	1.7	2.5 0.9	5.2
CLELUT	9	16.1	19.1 13.1	3.9	9	9.7	17.0 2.3	67.3	9	1.4	1.9 1.0	10.9
COMPOS	1	15.0	-	-	1	4.0	-	-	1	1.0	-	-
CRYPTA	20	6.8	7.9 5.6	8.5	20	267.7	449.9 85.5	134.8	20	84.6	178.1 -8.9	355.2
DISSTR	1	7.0	-	-	1	40.0	-	-	1	5.0	-	-
ERIOGO	12	5.9	6.6 2.9	2.4	12	45.5	59.8 5.2	16.1	12	4.4	5.7 3.2	12.7
EUPFEN	14	3.0	3.6 2.4	8.1	14	197.9	296.1 99.6	48.2	14	2.6	3.5 1.7	23.9

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

TABLE IV-14 (CONT.)
SAGEBRUSH/GREASEWOOD VEGETATION CHARACTERISTICS
SPRING 1976

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
FRAACA	16	7.2	8.7 5.7	10 1	16	164.7	266.4 63.0	86.6	16	11.9	20.6 3.2	121.2
GRASPI	45	37.4	40.0 34.9	3.2	51	1645.6	2028.2 1262.9	44.1	51	139.0	364.8 -86.8	2152.7
GRASPISD	-	-	-	-	1	50.0	-	-	1	1.0	-	-
GUTSAR	23	15.5	18.8 12.2	15.7	25	141.7	193.1 90.4	48.7	25	3.4	4.6 2.2	48.4
HALGLO	1	6.0	-	-	1	150.0	-	-	1	50.0	-	-
HILJAM	35	13.7	16.2 11.2	18.6	35	303.4	427.5 179.4	93.6	35	17.4	24.4 10.5	88.2
KOCSCO	3	10.7	16.8 4.5	7.7	3	1198.3	3906.7 -1510.1	119.8	3	68.3	195.3 -58.6	80.9
LEPFRE	25	33.5	37.6 29.4	5.6	25	42.4	60.7 24.0	69.7	25	1.6	2.0 1.3	18.6
LEPMON	6	11.0	20.9 1.1	55.5	6	14.8	29.1 0.6	63.5	6	5.0	9.8 0.2	62.3
LEPWAT	1	11.0	-	-	1	60.0	-	-	1	1.0	-	-
LITTER	-	-	-	-	199	4448.7	5150.6 3746.7	79.3	199	1.0	1.0 1.0	-
LUPINU	1	10.0	-	-	1	11.0	-	-	1	1.0	-	-
MELOFF	1	5.0	-	-	1	450.0	-	-	1	28.0	-	-
MENALB	15	13.8	16.0 11.6	5.5	15	112.9	187.8 38.1	92.9	15	55.5	86.8 24.3	67.0
OPURHO	15	13.2	16.0 10.4	9.6	15	195.9	272.3 119.4	32.2	15	2.1	3.2 1.1	50.1
ORYHYM	92	29.7	31.2 28.2	3.9	92	360.6	410.4 310.8	28.1	92	7.7	9.1 6.2	52.2
PENSTE	2	4.0	4.0 4.0	-	2	28.0	63.0 -7.0	15.9	2	1.0	1.0 1.0	-
PHLLON	4	4.8	5.8 3.7	1.8	5	53.0	69.1 36.9	4.9	5	20.2	31.1 9.3	15.4
POASAN	3	17.3	38.2 -3.6	34.0	3	41.7	99.4 -16.1	45.1	3	1.0	1.0 1.0	-
SALKAL	42	7.1	7.9 6.3	8.2	42	1834.8	2499.9 1169.7	88.3	42	910.3	1215.3 605.4	75.4
SARVER	53	52.9	57.6 48.3	6.6	66	1237.4	1513.2 961.5	52.5	66	1.7	2.0 1.5	21.7
SARVERSD	-	-	-	-	12	67.5	93.4 41.6	24.1	12	1.8	2.5 1.2	18.3
SISALT	2	17.5	54.0 -19.0	44.2	2	102.5	387.2 -182.2	78.3	2	6.5	16.7 -3.7	25.1
SISLIN	28	40.0	43.3 36.7	2.9	28	25.1	34.4 15.8	57.5	29	3.7	4.9 2.5	42.2
SITHYS	51	26.6	28.5 24.7	4.0	51	46.4	54.9 37.8	27.8	51	1.9	2.4 1.5	52.6
SPHCOC	10	10.8	12.9 8.7	5.2	10	50.8	64.9 36.7	10.2	10	3.1	5.1 1.1	54.5
SPHSUB	10	6.9	8.3 5.5	5.5	10	23.5	34.9 12.1	31.0	10	1.0	1.0 1.0	-
STPAU	2	18.0	53.0 -17.0	38.5	2	82.5	133.6 31.4	3.9	2	4.5	6.0 3.0	1.1
STICOM	39	30.0	32.5 27.4	4.5	39	500.1	612.0 388.2	31.2	39	12.4	15.8 9.0	46.8
SUANIG	12	26.7	34.3 19.1	13.2	12	175.9	252.9 99.0	31.3	12	3.1	4.8 1.3	53.4
TETGLA	3	40.7	42.2 39.1	-	3	466.7	1108.7 -175.3	44.4	3	2.7	6.6 -1.3	50.7
TETSPI	15	42.3	47.8 36.7	3.7	15	622.7	965.0 380.4	32.0	15	1.5	1.9 1.2	12.8

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

TABLE IV-15
JUNIPER VEGETATION TYPE CHARACTERISTICS
SPRING 1976

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
AGRDES	1	30.0	-	-	1	700.0	-	-	1	30.0	-	-
AGRINE	7	21.9	28.0 15.7	6.7	7	257.1	365.4 148.9	15.0	7	5.1	7.7 2.6	21.0
ARENAR	23	4.1	5.1 3.2	17.1	23	21.0	31.1 10.8	79.7	23	2.1	2.7 1.5	29.7
ARTNOV	85	15.2	16.4 14.1	7.8	85	975.1	1311.6 638.6	162.0	85	4.3	4.8 3.8	19.1
ARTNOVSD	28	4.8	5.6 3.9	13.1	66	105.8	137.7 73.9	96.1	66	3.8	4.5 3.4	40.8
ARTTRI	10	32.0	39.1 24.9	6.5	10	769.5	1547.0 -8.0	134.6	10	2.8	4.4 1.6	40.2
ARTTRISD	-	-	-	-	1	30.0	-	-	1	2.0	-	-
ASTRAG	13	7.6	10.5 4.7	26.4	13	27.2	37.6 16.8	26.2	13	1.1	1.2 0.9	2.9
ATRCON	30	18.9	21.7 16.0	10.2	32	194.2	250.7 137.8	43.3	32	1.3	1.5 1.1	12.3
ATRCONSD	19	5.7	6.4 5.0	4.2	39	46.2	57.3 35.2	35.6	39	1.5	1.7 1.3	11.6
BARGRO	-	-	-	-	198	34543.0	35449.6 33636.5	2.2	198	1.0	1.0 1.0	-
BORAGI	1	5.0	-	-	1	18.0	-	-	1	10.0	-	-
BROTEC	30	7.3	8.2 6.4	6.9	30	5.5	9.7 1.3	266.1	30	10.7	17.9 3.6	201.7
CASSCA	2	16.0	27.7 4.3	5.4	2	19.0	51.1 -13.1	29.0	2	1.5	3.0 0.0	9.6
CERLAN	1	12.0	-	-	1	100.0	-	-	1	1.0	-	-
CHRGRE	5	34.0	41.4 26.6	2.5	5	450.0	1031.4 -431.4	89.0	5	2.4	4.3 0.5	32.3
CHRNAU	4	37.8	36.9 18.6	4.1	4	462.5	850.2 74.8	26.8	4	1.0	1.0 1.0	-
CHRVIS	65	19.2	21.3 17.1	12.8	65	211.7	383.8 139.5	12.8	65	5.3	6.5 4.1	53.8
CHRVISSD	25	6.0	6.6 5.4	3.3	26	48.3	76.7 19.9	134.0	26	3.9	5.3 2.5	48.6
COMPOS	6	7.5	11.4 3.7	18.1	6	36.9	81.4 -7.7	100.5	6	1.5	2.2 0.8	13.5
CRYPTA	114	8.3	9.1 7.4	19.2	114	60.0	68.7 51.3	38.6	114	2.5	2.8 2.2	23.7
DISSTR	19	9.2	10.5 7.9	5.6	19	217.9	314.6 121.2	54.1	19	12.6	16.3 9.0	23.4
ECHINO	2	1.5	3.0 0.0	9.6	2	17.5	39.4 -4.4	15.9	2	1.0	1.0 1.0	-
EPHNEV	2	26.5	74.7 -21.7	33.6	2	80.0	109.2 50.8	1.4	2	1.0	1.0 1.0	-
ERICER	2	1.5	3.0 0.0	9.6	2	1.5	3.0 0.0	9.6	2	1.5	3.0 0.0	9.6
ERIGER	4	5.8	9.3 2.2	14.3	4	33.9	66.7 0.8	36.3	4	2.3	4.9 -0.4	53.4
ERIOGO	89	5.4	5.8 4.9	10.5	90	35.4	40.4 30.5	28.4	90	2.7	3.0 2.4	17.3
ERIOVA	17	4.2	5.5 3.0	21.6	17	44.9	57.4 32.4	18.8	17	2.4	3.7 1.1	73.5
EUPFEN	83	2.4	2.7 2.1	15.4	83	39.0	46.4 31.7	47.2	83	2.5	3.0 2.0	52.8
FORMEI	1	15.0	-	-	1	150.0	-	-	1	1.0	-	-
GILCAE	11	3.4	5.0 1.7	38.2	11	10.2	17.9 2.5	85.0	11	3.3	5.1 1.5	45.3
GILCON	4	1.5	2.6 0.4	19.2	4	18.3	28.1 8.4	11.1	4	1.0	1.0 1.0	-

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

TABLE IV-15 (CONT.)
JUNIPER VEGETATION TYPE CHARACTERISTICS
SPRING 1976

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
GILIA	1	7.0	-	-	1	10.0	-	-	1	1.0	-	-
GUTSAR	36	14.5	16.1 12.8	7.7	36	54.3	68.6 40.0	39.6	36	2.8	3.4 2.3	21.9
HALGLO	1	1.0	-	-	1	1.0	-	-	1	2.0	-	-
HEDBOR	47	20.7	22.9 18.5	8.7	48	159.7	198.6 120.7	45.7	48	1.7	2.0 1.4	20.8
HILJAM	36	8.2	9.1 7.2	7.7	36	214.3	253.6 175.0	19.4	36	11.4	13.7 9.1	23.6
JUNOST	59	213.1	239.2 186.9	14.2	98	15275.9	17424.4 13127.4	31.0	98	1.0	1.1 1.0	1.2
JUNOSTSD	-	-	-	-	5	297.0	853.4 -259.4	187.1	5	1.2	1.6 0.8	6.0
KOCAME	1	14.0	-	-	1	50.0	-	-	1	6.0	-	-
LEGUMI	2	30.0	59.2 0.8	9.6	2	17.5	39.4 -4.4	15.9	2	2.0	4.9 -0.9	21.6
LEPFRE	53	21.1	24.1 18.0	18.0	53	26.1	33.4 18.7	68.1	53	3.3	4.0 2.6	41.2
LEPPER	3	6.3	13.0 -0.4	26.3	3	151.7	443.9 -140.5	87.0	3	6.3	12.7 -5.1	75.9
LEPPUN	13	6.5	9.1 4.0	27.6	13	163.4	260.3 66.5	63.1	13	3.3	4.8 1.8	35.2
LEPWAT	2	2.0	2.0 2.0	-	2	13.5	23.7 3.3	5.8	2	1.5	3.0	9.6
LITTER	-	-	-	-	197	3279.3	4099.1 2459.4	197.0	197	1.0	1.0 1.0	-
MACGRI	9	14.9	19.5 10.3	11.1	9	40.9	72.0 9.8	67.1	9	1.2	1.6 0.8	12.9
MELOFF	1	20.0	-	-	1	60.0	-	-	1	2.0	-	-
OENCAE	12	2.3	3.2 1.3	28.2	12	18.3	23.5 13.0	13.4	12	1.5	1.9 1.1	12.2
OPURHO	5	7.4	10.6 4.2	10.1	5	126.0	221.1 30.9	30.3	5	1.6	2.4 0.8	13.5
ORYHYM	97	18.3	19.6 16.9	8.8	98	303.3	532.4 74.3	894.1	98	4.3	5.2 3.4	70.8
PENSTE	1	3.0	-	-	1	20.0	-	-	1	1.0	-	-
PETPUM	41	10.9	12.2 9.7	8.4	41	216.2	265.3 167.1	33.9	41	4.2	5.1 3.4	29.3
PHLOX	2	11.0	25.6 -3.6	17.9	2	22.0	74.6 -30.6	58.0	2	2.5	6.9 -1.9	31.2
PHYNEW	33	3.1	3.4 2.7	5.8	33	19.4	26.3 12.5	66.5	33	1.7	2.0 1.4	15.3
PINEDU	3	62.7	198.4 -73.0	110.0	3	3337.7	11175.9 -4500.6	129.4	3	1.7	3.2 0.1	20.8
POASAN	25	7.7	8.9 6.5	9.0	25	50.0	68.0 31.9	48.6	25	3.4	4.4 2.5	29.0
SARVER	2	64.0	198.3 -70.3	44.7	3	210.0	492.7 -72.7	42.5	3	1.0	1.0 1.0	-
SISALT	1	25.0	-	-	1	5.0	-	-	1	1.0	-	-
SISLIN	15	20.5	25.0 16.0	10.3	15	19.3	31.2 7.5	79.5	15	8.7	14.5 2.9	94.3
SITHYS	19	18.5	21.1 15.9	5.5	19	69.0	123.3 14.7	170.3	19	5.8	8.5 3.2	57.2
STICOM	10	23.2	30.5 15.9	13.1	10	250.9	509.4 -7.6	140.0	10	8.3	14.3 2.3	68.7
STRCOR	32	7.3	10.0 4.7	67.5	32	18.6	25.5 11.8	69.2	32	1.8	2.3 1.3	37.6
THEFLE	1	13.0	-	-	1	18.0	-	-	1	1.0	-	-

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

TABLE IV-16
SHADSCALE VEGETATION CHARACTERISTICS
SPRING 1976

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
AGRINE	1	30.0	-	-	1	100.0	-	-	1	4.0	-	-
ARTFRI	4	13.0	21.6 4.4	16.6	4	82.8	141.9 23.6	19.5	4	2.5	4.4 0.7	20.8
ARTNOV	22	19.9	21.6 18.3	2.2	22	812.8	1068.3 557.2	31.9	22	2.2	2.6 1.7	13.5
ARTNOVSD	-	-	-	-	3	21.3	55.2 -12.5	59.0	3	3.0	5.7 0.3	19.2
ARTSPI	22	11.1	13.3 8.8	13.2	24	196.8	242.3 151.3	19.0	24	2.7	3.5 2.0	26.9
ARTTRI	89	36.0	38.0 34.0	4.4	92	1368.9	1527.7 1210.1	19.8	92	2.7	3.0 2.4	20.3
ARTTRISD	2	2.5	6.9 -1.8	31.2	35	59.4	102.8 16.0	298.7	35	5.9	8.1 3.7	77.4
ASTCHI	10	13.1	16.9 9.3	11.0	10	9.4	13.0 5.8	19.1	10	1.3	1.7 0.9	11.7
ASTMEG	1	4.0	-	-	1	50.0	-	-	1	1.0	-	-
ASTRAG	7	7.1	10.5 3.8	18.8	8	26.0	46.2 5.8	60.6	8	1.8	2.3 1.2	11.1
ATRCON	163	20.7	21.8 19.7	6.6	165	559.9	651.0 468.8	69.9	165	3.2	3.5 3.0	18.0
ATRCONSD	7	7.0	7.7 6.3	1.0	80	34.5	46.5 22.5	155.7	80	2.5	2.9 2.1	32.5
ATRIPL	-	-	-	-	2	35.0	78.8 -8.8	15.9	2	35.0	78.8 -8.8	15.9
BARGRO	-	-	-	-	199	37633.3	37785.8 37480.8	1.0	199	1.0	1.0 1.0	-
BROTEC	88	10.2	10.7 9.7	2.8	93	229.3	326.6 132.0	268.1	93	491.1	693.2 289.0	252.0
CERLAN	1	18.0	-	-	1	50.0	-	-	1	2.0	-	-
CERLANSD	2	5.5	7.0 4.0	-	3	12.0	27.7 -3.7	40.0	3	1.0	1.0 1.0	-
CHADOU	11	7.0	8.4 5.6	5.8	12	59.3	133.8 -15.3	258.8	12	9.5	16.2 2.8	81.8
CHRGRE	2	14.5	18.9 10.1	1.0	2	275.0	786.0 -236.0	35.1	2	3.0	5.9 0.1	9.6
CHRGRESO	-	-	-	-	1	5.0	-	-	1	1.0	-	-
CHRNAU	3	35.0	43.5 26.5	1.4	4	312.5	734.7 -109.7	69.5	4	1.0	1.0 1.0	-
CHRNAUSD	-	-	-	-	2	8.5	18.7 -1.7	14.7	2	1.5	3.0 -	9.6
CHRVIS	21	32.2	37.2 27.3	7.2	21	771.2	1020.7 521.6	32.1	21	2.0	2.5 1.4	22.1
CHRVISSD	2	4.5	8.9 0.1	9.6	6	18.3	32.6 4.1	41.7	6	1.8	2.6 1.1	12.4
CRYGRM	-	-	-	-	59	140.4	200.5 80.3	172.9	59	1.6	1.9 1.3	24.8
CRYPTA	3	12.3	25.7 -1.1	27.7	4	10.0	17.4 2.6	20.8	4	1.0	1.0 1.0	-
ERIMIC	2	25.0	39.6 10.4	3.5	2	275.0	932.0 -382.0	58.0	2	1.0	1.0 1.0	-
ERIOGO	34	13.3	15.8 10.7	20.5	38	302.2	387.8 216.7	48.7	38	3.6	4.4 2.8	27.1
ERIOVA	1	10.0	-	-	1	75.0	-	-	1	3.0	-	-
EUPFEN	14	6.1	10.8 1.5	109.9	16	59.1	81.5 36.6	32.7	16	3.2	4.7 1.7	51.8
GILCON	1	22.0	-	-	1	10.0	-	-	1	1.0	-	-
GILINC	4	39.0	49.8 28.2	2.9	4	38.0	83.2 -7.2	53.9	4	1.8	2.8 0.7	13.0
GUTSAR	69	15.0	16.5 13.5	10.7	71	174.1	234.7 113.5	137.4	71	5.9	7.4 4.5	69.1

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

TABLE IV-16 (CONT.)
SHADSCALE VEGETATION CHARACTERISTICS
SPRING 1976

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
HALGLO	6	4.3	5.6 3.0	6.1	18	34.2	54.5 13.8	60.4	18	19.8	29.4 10.3	60.4
HILJAM	23	17.6	21.4 13.8	15.9	23	378.4	595.0 161.9	111.0	23	5.7	8.0 3.5	52.0
ITTER	-	-	-	-	1	1000.0	-	-	1	1.0	-	-
KOCAME	1	14.0	-	-	1	200.0	-	-	1	8.0	-	-
LAPRED	10	4.9	5.7 4.1	3.8	11	5.2	8.2 2.2	48.6	11	5.2	6.2 4.2	5.7
LEPFRE	29	30.6	34.1 27.1	5.7	29	41.8	58.5 25.1	69.3	29	2.3	2.9 1.7	27.9
LEPIDT	1	8.0	-	-	1	2.0	-	-	1	1.0	-	-
LEPHON	4	22.3	35.3 9.2	13.1	5	24.0	45.9 2.1	44.4	5	7.0	18.6 -4.6	146.2
LITTER	-	-	-	-	196	445.0	489.4 400.5	31.3	196	1.0	1.0 1.0	-
MENALB	1	10.0	-	-	1	2.0	-	-	1	1.0	-	-
OENCAE	8	3.6	4.1 3.1	1.8	10	34.3	51.8 16.8	34.3	10	1.7	2.2 1.2	10.2
OPURHD	18	8.7	10.1 7.3	6.6	18	100.3	133.1 67.6	27.6	18	1.5	1.8 1.2	11.9
ORYHYM	49	19.1	21.0 17.2	7.9	49	73.1	93.1 53.1	58.7	49	2.7	3.2 2.2	24.6
PHACEL	2	8.0	13.8 2.2	5.4	2	2.0	2.0 2.0	-	2	1.0	1.0 1.0	-
SALKAL	2	8.0	28.4 -12.4	66.3	17	16.1	22.9 9.3	43.5	17	13.8	19.8 7.9	44.7
SARVER	13	38.5	48.3 28.8	11.5	16	560.9	795.0 326.9	39.6	16	1.2	1.4 1.0	5.0
SARVERSD	-	-	-	-	3	41.7	61.3 22.1	5.2	3	1.3	2.1 0.6	8.1
SISALT	3	28.7	39.7 17.7	3.4	3	5.0	5.0 5.0	-	3	2.3	4.4 0.3	18.6
SISLIN	7	44.1	52.6 35.7	3.1	7	12.7	24.8 0.6	76.3	7	1.6	2.1 1.0	10.9
SITHYS	47	23.3	25.3 21.2	6.1	47	33.1	50.6 15.7	208.8	47	1.8	2.1 1.6	12.0
SPHCOC	34	11.1	12.7 9.6	10.8	35	56.1	102.2 9.9	379.1	35	1.9	2.3 1.6	18.8
SPHSUB	4	5.5	7.5 3.5	5.2	4	4.3	6.1 2.4	7.0	4	1.3	1.8 0.7	6.9
STEPAU	5	15.8	21.4 10.2	6.8	5	68.6	143.1 -5.9	62.8	5	2.2	3.2 1.2	10.7
STICOM	3	26.3	42.4 10.2	8.8	3	45.0	96.3 -6.3	30.5	3	1.7	2.5 0.9	5.2
SUANIG	4	27.5	37.7 17.3	5.2	4	337.5	744.3 -69.3	55.3	4	3.3	5.6 0.9	20.1
TETAXI	7	40.4	50.9 29.9	5.7	10	466.1	854.0 78.2	91.3	10	1.3	1.7 0.9	11.7
TETGLA	7	46.7	52.8 40.6	1.5	8	625.6	1066.7 184.6	49.7	8	1.6	2.4 0.8	23.1
TETSPI	25	38.7	42.8 34.6	4.1	25	908.2	1180.4 636.0	33.3	25	1.8	2.2 1.4	16.7
TETSPISD	-	-	-	-	3	175.0	499.0 -149.0	80.4	3	1.3	2.1 0.6	8.1
TOWNSE	1	5.0	-	-	1	3.0	-	-	1	1.0	-	-

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

TABLE IV-17
RIPARIA VEGETATION CHARACTERISTICS
SPRING 1976

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
ACHMIL	1	12.0	-	-	1	5.0	-	-	1	1.0	-	-
AGUSEK	1	14.0	-	-	1	455.0	-	-	1	23.0	-	-
AGRINE	79	47.6	50.5 44.7	4.8	79	528.7	639.4 418.0	55.4	79	33.4	41.9 25.1	79.7
AGRREP	6	41.2	50.2 32.1	3.3	6	129.7	297.1 -37.8	114.7	6	20.3	28.5 12.1	11.2
AGRSMI	1	60.0	-	-	1	350.0	-	-	1	3.0	-	-
ALOPRA	1	7.0	-	-	1	200.0	-	-	1	52.0	-	-
AMBPSI	12	8.8	11.1 6.6	11.0	12	86.3	145.6 26.9	77.4	12	26.6	43.3 7.8	78.7
ARTTRI	14	111.8	132.8 90.8	6.9	17	2838.5	3629.3 2047.8	18.9	17	4.2	5.4 3.1	18.0
ATRCAN	3	85.3	178.9 -8.2	28.2	4	5025.0	14400.0 -4350.0	132.6	4	1.0	1.0 1.0	-
ATRPAT	65	16.5	18.2 14.8	11.6	65	110.4	163.8 57.0	243.5	65	17.9	26.7 9.1	252.1
BARGRO	0	-	-	-	93	8347.8	10269.3 6426.3	78.8	93	1.0	1.0 1.0	-
BORAGI	2	18.5	31.6 5.4	5.1	2	7.5	14.8 0.2	9.6	2	2.5	4.0 1.0	3.5
BROTEC	139	25.1	26.5 23.8	6.4	140	1513.0	1909.3 1116.8	153.6	140	1265.9	1493.8 1038.1	72.5
CAREX	3	31.3	36.8 25.8	-	3	196.7	438.3 -45.0	35.4	3	10.0	17.0 2.9	11.7
CHADOU	2	6.0	3.9 3.1	2.4	2	5.5	18.6 -7.6	58.0	2	2.5	6.9 -1.9	31.2
CHOTEN	7	14.4	21.3 7.6	19.0	7	245.7	552.7 -61.3	131.7	7	58.4	143.2 -26.4	177.6
CHRNAU	55	86.7	95.9 77.6	9.8	61	1289.9	1592.5 987.3	53.7	61	1.7	1.9 1.4	22.0
CHRNAUSD	4	5.5	6.9 4.1	2.4	11	142.4	391.6 -106.9	452.4	11	2.5	3.9 1.1	47.9
CHRVIS	72	85.0	94.3 75.7	13.8	73	2540.7	3512.2 1569.2	170.8	73	4.7	5.4 4.0	25.9
CHRVISD	-	-	-	-	1	10.0	-	-	1	2.0	-	-
CIRSIU	10	16.8	24.9 8.8	30.3	10	256.8	531.7 -20.1	153.3	10	12.8	24.0 1.6	101.1
CLELIG	3	57.3	90.5 24.1	7.9	4	148.3	263.4 33.1	23.0	4	1.8	3.4 0.1	31.8
CLELUT	11	26.8	32.1 21.6	5.6	11	18.4	24.7 12.0	17.6	11	2.1	2.8 1.4	16.7
COMPAL	49	17.6	18.9 16.3	4.5	49	121.7	166.7 76.7	107.3	49	20.6	28.9 12.2	129.3
CRYGRM	-	-	-	-	3	993.3	1748.5 238.1	13.6	3	1.0	1.0 1.0	-
DISSTR	85	20.9	22.3 19.5	6.0	85	627.6	992.8 262.4	460.6	85	95.7	119.5 71.9	84.3
EQUARV	18	39.8	46.5 33.2	7.2	18	281.2	453.6 108.8	97.4	18	259.4	433.5 85.3	116.8
FES OCT	1	2.0	-	-	1	360.0	-	-	1	8351.0	-	-
GILCON	2	16.5	53.0 -20.0	49.7	2	117.5	431.4 -196.4	72.5	2	14.5	45.2 -16.2	45.4
HALGLO	6	5.7	7.1 4.3	4.1	6	5.0	7.2 2.8	9.1	6	4.2	5.3 3.0	5.4
HORJUB	1	42.0	-	-	1	20.0	-	-	1	2.0	-	-
JUNBAL	10	38.0	47.1 28.9	7.6	10	61.6	110.2 13.0	82.1	10	101.6	151.8 51.4	32.2
KOCSCO	30	8.6	10.3 7.0	16.6	30	167.5	275.6 59.4	187.7	30	203.0	402.5 3.4	435.8
LAPRED	6	19.2	28.2 10.1	15.4	6	18.0	34.0 2.0	54.4	6	16.0	26.9 5.1	31.8

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

TABLE IV-17 (CONT.)
RIPARIA VEGETATION CHARACTERISTICS
SPRING 1976

Species	Height (cm)				Cover (cm ² /4m ²)				Density (individual/4m ²)			
	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE	NUM OBS	MEAN	90% C.I.	SAMPLE SIZE
LEPFRE	1	35.0	-	-	1	25.0	-	-	1	4.0	-	-
LEPIDT	34	28.3	34.1 22.4	23.1	34	61.2	116.7 5.6	448.6	34	17.6	22.7 12.4	47.4
LEPPER	24	13.9	17.5 10.3	23.4	24	192.6	374.5 10.7	316.5	24	126.0	221.6 30.4	204.2
LITTER	-	-	-	-	195	31560.4	32759.6 30361.3	4.5	195	1.0	1.0 1.0	-
MALAFR	2	6.0	8.9 3.1	2.4	2	30.5	90.4 -29.4	39.1	2	26.0	40.6 11.4	3.2
MELOFF	64	35.4	39.7 31.2	14.5	65	620.8	753.9 287.6	208.5	65	33.9	46.9 20.8	155.0
MULASP	1	15.0	-	-	1	780.0	-	-	1	26.0	-	-
ORYHYM	4	25.8	39.6 11.9	11.0	4	1.5	2.1 0.9	6.4	4	2.0	3.5 0.5	21.6
PHACEL	6	12.8	16.9 8.8	6.9	6	153.7	383.3 -75.9	153.6	6	106.2	292.0 -79.6	210.7
PHRCOM	2	72.0	118.7 25.3	4.3	2	140.0	373.6 -93.6	28.3	2	21.0	76.5 -34.5	70.9
PLAPUR	3	9.3	15.0 3.7	8.6	3	7.3	11.5 3.2	7.5	3	9.0	15.8 2.2	13.4
POAPRA	29	61.0	66.7 55.3	3.7	29	820.9	1117.2 524.5	56.7	29	321.1	458.4 183.8	79.5
POASAN	2	27.0	88.3 -34.3	52.4	2	27.5	93.2 -38.2	58.0	2	2.0	4.9 -0.9	21.6
POPANG	-	-	-	-	1	600.0	-	-	1	1.0	-	-
POPFRE	22	679.8	881.7 477.9	28.5	70	18557.7	21323.3 15792.1	24.9	70	1.6	1.8 1.3	37.6
RHUTRI	2	38.0	125.6 -49.6	54.0	2	617.5	2406.0 -1171.0	85.2	2	1.0	1.0 1.0	-
SALEXI	11	179.2	265.9 92.4	34.6	14	895.7	1496.9 294.5	88.0	14	1.5	2.1 0.9	31.8
SALKAL	31	10.1	11.4 8.8	8.3	31	117.6	166.2 68.9	84.8	31	63.9	90.4 37.4	85.4
SARVER	13	106.1	140.1 72.0	18.5	21	3804.9	5597.9 2012.0	68.1	21	1.1	1.2 1.0	3.3
SARVERSD	-	-	-	-	1	3.0	-	-	1	1.0	-	-
SCIAME	3	34.3	47.0 21.7	3.2	3	52.0	155.9 -52.0	93.8	3	8.0	16.3 -0.3	25.0
SISLIN	1	34.0	-	-	1	30.0	-	-	1	29.0	-	-
SITHYS	3	59.0	67.5 50.5	-	3	406.7	508.6 304.7	1.5	3	10.3	16.0 4.7	7.0
SPOAIR	13	29.4	34.4 24.4	5.3	13	617.7	851.7 383.7	25.7	13	2.2	3.0 1.5	20.5
SPOCRY	5	13.4	19.2 7.6	9.8	5	21.0	35.0 7.0	23.8	5	3.4	6.4 0.4	40.4
STPAU	1	10.0	-	-	1	5.0	-	-	1	3.0	-	-
TAMPEN	32	320.8	385.9 255.7	21.1	38	3141.9	4598.3 1685.6	130.6	38	4.5	5.8 3.2	52.8
TAMPENSD	1	7.0	-	-	1	15.0	-	-	1	3.0	-	-
TAROFF	23	14.7	18.2 11.2	19.7	23	570.5	938.7 202.2	141.2	23	21.6	36.1 7.1	152.8
TRADUB	7	48.0	55.1 40.9	1.8	7	14.9	18.4 11.4	4.7	7	2.4	3.2 1.6	9.4
XANSTR	1	8.0	-	-	1	15.0	-	-	1	1.0	-	-

DATA ARE FOR THE NUMBER OF OBSERVATIONS, MEAN, 90% CONFIDENCE INTERVAL ABOUT THE MEAN AND SAMPLE SIZE REQUIRED TO ESTIMATE WITHIN 25% OF THE MEAN WITH A 90% STATISTICAL CONFIDENCE.

Hillside Juniper

Steeply sloping hillsides in the juniper vegetation type were not sampled using the regular vegetation sampling procedures because of their obviously different characteristics in topography. To have included these steep areas with the other juniper vegetation sampling sites would not have been scientifically defensible because of the disparity in topography and plant density. Instead, a separate sampling program was developed for these areas.

The sampling method consisted of a 4-m-wide transect extending downhill for a distance of 25 m (for a plot size of 100m^2). A recorder and vegetation analyst travelled downhill recording the presence of species and the area covered. A total of twelve 100-m^2 plots were chosen for study by first identifying steep slopes in the juniper vegetation type on a topographic map and then by establishing a starting point along the ridge tops in random fashion. All plots sampled were in sections 28 and 29 on Tract U-a on east-, southeast- and west-facing slopes. Sampling was conducted in June 1976. Data from the 12 plots are given on Table IV-18.

Because many of the species occurred infrequently, it was impossible to determine sampling adequacy on the steep slopes, even with a plot size of 100m^2 . Table IV-18 shows the kinds of species present in addition to the juniper trees and occasional big sagebrush (*Artemisia tridentata*), rabbitbrush (*Chrysothamnus viscidiflorus*), and serviceberry (*Amelanchier utahensis*).

The average cover of plants on steeply sloping areas in the juniper vegetation types was 7.19%, with a standard deviation of 3.82% (Table V-19). The percentage of vegetative cover on the various plots ranged from a low of less than 1% to a high of 15.2%. A large amount of bare sandstone and talus material on plot 11 apparently prevented plants from developing in all but a few favorable locations. A mat-forming perennial, buckwheat (*Eriogonum*), provided the most ground cover. In contrast, the understory of perennial grasses, shrubs, and forbs on plot 9 provided about equal cover with juniper for a total 11% cover. Another pattern of cover in relation to the various species is seen on plot 8, in which the major amount of cover (14.4%) was provided by juniper, with only a very minor portion (1.29%) covered by all other species.

Plant densities varied according to the individual species involved, ranging from a high of 38 plants per 100m^2 for black sage (*Artemisia nova*) to 0.75 for serviceberry (*Amelanchier*

TABLE IV-18

VEGETATION ANALYSES OF STEEPLY SLOPING AREAS IN THE JUNIPER VEGETATION TYPE. Data shown are percent cover of species encountered in each 4m x 25m transect (100 m² plot).

Plot 1		Plot 2		Plot 3		Plot 4		Plot 5		Plot 6	
Species	% Cover	Species	% Cover	Species	% Cover	Species	% Cover	Species	% Cover	Species	% Cover
AGRINE	.0605	AGRINE	.0105	AGRINE	.2495	AGRINE	.4282	AGRINE	.0060	AREVAR	.0039
ARTNOV	.5980	ARTNOV	.7835	AMELAN	.9350	AMELAN	1.7600	AREVAR	.0110	ARTNOV	.2282
ASTRAG	.0612	ASTRAG	.2378	ASTRAG	.0127	ARTNOV	.0525	AREVAR	1.2448	ASTRAG	.0010
ATROON	.2204	ATROON	.2235	BRUCE	.1650	ASTRAG	.0402	ASTRAG	.0018	ATROON	.1925
CHRNAU	.0285	CHRNAU	.0950	CHRNAU	.0750	BRUCE	.0360	ATROON	.2812	BROTEC	.0004
CHRVIS	.4226	CHRVIS	.5451	CHRVIS	.0250	CHRVIS	.0100	BROTEC	.0028	CHRVIS	.0460
CRYPTA	.0419	CRYPTA	.0140	CRYPTA	.0162	CRYPTA	.0181	CHRVIS	.4477	CRYPTA	.0027
EPINEV	.1250	EPINEV	.0570	EPINEV	.0275	EPINEV	.1190	CRYPTA	.0064	ERIOGO	.0895
ERIOGO	.3535	ERIOGO	.0710	ERIOGO	.0450	ERIOGO	.1190	EPINEV	.0275	EUPFEN	.0469
GALIUM	.0955	ERIGER	.1680	EUPFEN	.0148	EUPFEN	.0035	ERIGER	.0045	HEDBOR	.1220
GUTSAR	.0450	EUPFEN	.0405	GALIUM	.1969	GUTSAR	.0213	ERIOGO	.0475	HILLJAM	.1692
HEDBOR	.1700	GALIUM	.0315	HEDBOR	.0570	HEDBOR	.0700	EUPFEN	.0243	JUNOST	5.6000
JUNOST	2.5000	GUTSAR	.2805	HILLJAM	.0100	HILLJAM	.0040	HEDBOR	.2478	LEPPRE	.0024
LEPPUM	.0050	HEDBOR	.6415	JUNOST	5.2000	JUNOST	1.4500	JUNOST	4.4442	LEPPUN	.0505
MACHAE	.0080	HILLJAM	.2990	LEPPUN	.1390	LEPPUN	.0520	LEPPRE	.0015	ORYHYM	.0815
ORYHYM	.5790	HYMACA	.0075	MACHAE	.0405	MACHAE	.0750	LEPPUN	.0349	PETPUM	.1238
PENSTE	.0010	JUNOST	3.0000	ORYHYM	.0615	PETPUM	.0057	MACHAE	.0120	Total	6.76
PHYAUS	.0030	LEPPRE	.0175	PETPUM	.1210	STRCOR	.0057	ORYHYM	.3209		
SISLIN	.0020	LEPPUN	.0130	STEPAU	.0004	Total	4.29	PETPUM	.3150		
STEPAU	.0020	MACHAE	.2655	Total	7.39			PHYAUS	.0003		
STRCOR	.0093	ORYHYM	.5375					SISLIN	.0025		
Total	5.29	PENSTE	.0005					STRCOR	.0013		
		PETPUM	.4810					TETNUT	.0330		
		PHYAUS	.0260					Total	7.52		
		STEPAU	.0100								
		STRCOR	.0015								
		Total	7.86								

TABLE IV-18 (continued)

Plot 7			Plot 8			Plot 9			Plot 10			Plot 11			Plot 12		
Species	%	Cover	Species	%	Cover	Species	%	Cover	Species	%	Cover	Species	%	Cover	Species	%	Cover
AGRINE		.3294	AGRINE		.0078	AGRINE		1.1400	AGRINE		.3190	AGRINE		.0856	AGRINE		.1635
AMELAN		3.6000	ARTNOV		.0430	ARTNOV		1.6735	ARTNOV		.6845	ARTNOV		.1445	AMEUTA		.0500
AREVAR		.0063	ASTRAG		.0156	ATRCON		.3216	ASTRAG		.0430	ARTNOV		.0160	ASTRAG		.0007
ARTNOV		.1163	ATRCON		.0830	CHRNAU		.0750	ATRCON		.3120	ARTTRI		.0010	BROTTEC		.0200
ASTRAG		.0124	CHRGRE		.0030	CHRNAU		.3250	CHRNAU		.0250	BRIMIC		.0150	CHRNAU		.0010
BRICKE		.0080	CHRVIS		.4861	CHRVIS		.0025	CHRVIS		.1710	CHRVIS		.0875	CHRVIS		.0700
CRYPTA		.0775	CRYPTA		.0103	ERIOGO		.2955	EPHNEV		.0075	CORTEN		.0050	CRYPTA		.0050
CRYPTA		.0140	EPHNEV		.0100	GALJUM		.0050	ERIOGO		.1470	CRYPTA		.0080	ERIOGO		.0270
ERIMIC		.1486	ERIMIC		.2113	GUTSAR		.0600	EUPFEN		.0283	EPHNEV		.0100	EUPFEN		.0035
ERIOGO		.0060	ERIOGO		.0446	HEDBOR		.1180	GALJUM		.0425	ERIOGO		.2250	GALJUM		.0020
EUPFEN		.0030	EUPFEN		.0075	JUNOST		6.8780	GUTSAR		.1990	GILINC		.0048	GILINC		.0135
HEDBOR		.1520	HEDBOR		.0035	LEPPUN		.0685	HEDBOR		.3615	GILINC		.0100	GUTSAR		.0050
JUNOST		4.3000	HILJAM		.1376	MACHAE		.0325	HILJAM		.2110	GUTSAR		.0025	HEDBOR		.0050
LEPPUN		.1572	JUNOST		14.4000	ORYTHM		.0125	JUNOST		4.5000	HEDBOR		.0050	HILJAM		.0640
MACHAE		.0707	LEPPUN		.0288	PETPUM		.0050	LEPFRE		.0090	JUNOST		.1000	JUNOST		2.5000
PETPUM		.0100	MACHAE		.0375	PHYAUS		.0012	LEPPON		.0005	ORYTHM		.0950	LEPPUN		.0090
PHYAUS		.0020	ORYTHM		.1117	RANTES		.0045	LEPPUN		.0550	ORYTHM		.0010	MACHAE		.0435
Total	%	9.00	PETPUM		.0535	Total	%	11.01	MACHAE		.2640	Total	%	.82	ORYTHM		.0050
			STRCOR		.0003				PETPUM		.3110				STRCOR		.0525
			Total	%	15.20				RANTES		.1825				Total	%	3.12
									Total	%	7.53						

TABLE IV-19

PLANT COVER AND DENSITY ON STEEPLY SLOPING HILL-SIDES IN THE JUNIPER VEGETATION TYPE. Data are the means of twelve 4m x 25m transects (100 m² plots).

Species	% Cover	Standard Deviation	Density (No. plants per 100 m ²)	Standard Deviation
AGRINE	0.23	0.32	35.92	45.81
AMELAN	0.53	1.11	0.75	1.22
ARTNOV	0.45	0.56	38.83	42.95
ASTRAG	0.03	0.07	12.75	19.67
ATRCON	0.14	0.13	13.91	15.58
BRICKE	0.02	0.05	1.17	1.85
CHRVIS	0.23	0.20	17.75	17.91
EPHNEV	0.03	0.05	2.25	2.77
ERIOGO	0.13	0.11	24.92	22.49
GUTSAR	0.05	0.09	9.83	17.25
HEDBOR	0.16	0.18	10.67	11.60
HILJAM	0.07	0.10	42.35	65.32
JUNOST	4.50	3.62	2.58	1.56
LEPPUN	0.05	0.05	18.83	21.46
MACHAE	0.07	0.09	14.17	21.86
ORYHYM	0.18	0.20	32.75	35.09
Other species	<u>0.21</u>	--	--	--
TOTAL	7.19			

utahensis). The density of juniper was 2.58 plants per 100m² (0.0258 per square meter), which was considerably less than the 56 plants found in one-hundred 4-m² plots, as reported for less steep juniper hillsides.

Translating these values to an equivalent square meter basis yields an average juniper density of 0.0258 plants per square meter for the steeply sloping hillsides and 0.14 plants per square meter for the moderately sloping hillsides that are more typical of the juniper type.

The values obtained for cover and plant density on the steeply sloping hillsides have considerable relevance for the revegetation program. The results of the program indicate that providing a plant cover similar to that in the juniper vegetation type would require a plant cover of about 7% for steep-sloping lands and about 16.7% for moderate slopes. Discounting the presence of annual vegetation, as would be the case if data for a fall sampling period were used, a plant cover of 7.5% in the juniper type would be appropriate for a revegetation goal.

c. Interpretation and Conclusions

Even though many interpretations and conclusions were drawn from the results, it was difficult to compare seasons and years of sampling because data have been collected just for the two-year period. For example, although years of favorable precipitation in the early growing season and moderate temperatures during critical growth stages are important to plant survival and succession, the effects of such environmental influences are not apparent until years later, if at all.

The most obvious measure of environmental effects on vegetation is the amount of bare ground in each type in the spring and fall (Table IV-20). Only an average of 15% to 20% of the ground had a vegetative canopy, and in a dry year or in the fall the amount of cover may decrease, as indicated by a 6% reduction in the shadscale vegetation type in spring 1976.

The presence of large numbers of annual plants and greater growth of perennials in 1975 compared with 1976 is important. In the riparian type, the decrease in height, cover, and density of cheatgrass (*Bromus tectorum*) reflects the effects of the less favorable conditions in 1976 compared with those of 1975: the average height in 1975 was 36 cm as compared with 25 cm in 1976; cover in 1975 was 0.72 m²/4m² as compared with 0.19 m²/4m² in 1976; and density per plot was 1900 plants/4m² in 1975 as compared with 1265 in 1976. Other species showed similar differences.

The data concerning community structure and composition indicate

TABLE IV-20

PERCENT OF BARE GROUND OBSERVED IN EACH OF FOUR VEGETATION
TYPES IN SPRING AND FALL SAMPLING PERIODS.

Sampling Period Season, Year	Vegetation Type			
	Sagebrush/ Greasewood	Juniper	Shadscale	Riparian
Fall, 1974	84.3	85.6	90.3	22.1
Spring, 1975	87.4	80.3	84.1	16.5
Fall, 1975	84.5	81.9	69.3	16.3
Spring, 1976	78.5	86.4	94.1	20.8

significant differences in the proportion of various species in each vegetation type. Such differences are expressed in the amount of cover, the frequency of occurrence, and the number of plants per unit area.

Sagebrush-greasewood

The dominant shrubs in the sagebrush-greasewood community are big sagebrush (*Artemisia tridentata*), greasewood (*Sarcobatus vermiculatus*), and shadscale (*Atriplex confertifolia*). Other major shrubs associated with the community include horsebrush (*Tetradymia* spp.), hop sage (*Grayia spinosa*), and black sage (*Artemisia nova*). The dominant herbaceous species persisting into fall include Russian thistle (*Salsola kali*), snake weed (*Gutierrezia sarothrae*), and rabbitbrush (*Chrysothamnus* spp.). Both Russian thistle and rabbitbrush are indicative of heavily grazed if not overgrazed vegetation. *Chrysopsis* (*Chrysopsis* spp.), fleabane (*Erigeron engelmannii*), prickly pear (*Opuntia* spp.), and winterfat (*Eurotia lanata*) are other major species.

Cheatgrass (*Bromus tectorum*) is the dominant grass in the spring. Indian ricegrass (*Oryzopsis hymenoides*), needle-and-thread grass (*Stipa comata*), and Galleta grass (*Hilaria jamesii*) are sub-dominant grasses which persist into fall and represent the dominant fall grasses. Cheatgrass and needle-and-thread grass provide good forage while young, but are poor forage when mature. The borage family (*Boraginaceae* spp.) and mustard family (*Cruciferae* spp.) provided the dominant spring herbs. *Mentzelia* (*Mentzelia albicaulis*), squirrel tail grass (*Sitanion hystrix*), Cleome (*Cleome lutea*), and red sage (*Kochia americana*) are other major species appearing in the spring.

Juniper

The juniper community is dominated by Utah juniper (*Juniperus osteosperma*). Only four pinyon pines (*Pinus edulis*) were encountered during the field sampling. Black sage and to a lesser extent shadscale and big sage are the major shrubs. Snakeweed, spurge (*Euphorbia* spp.), wild buckwheat (*Eriogonum* spp.), rabbitbrush, and fleabane are the major herbaceous species persisting into fall.

Galleta grass and Indian rice grass are the dominant grasses in the spring and persist into fall. Spring herbs are dominated by the borage family, wild buckwheat, red sage, and sweet vetch (*Hedysarum boreale*). Other spring species include pepper grass (*Lepidium montanum*) and other species in the mustard family, needle-and-thread grass, Kentucky bluegrass (*Poa pratensis*), cheatgrass, phlox (*Phlox hoodii*), and lambs quarter (*Chenopodium album*).

Shadscale

The dominant shrubs of the shadscale community are shadscale and big sage. The other major shrubs include black sage, greasewood, and to a lesser extent hop sage and horsebrush (*Tetradymia spinosa*). Herbaceous species persisting into fall include rabbitbrush, snakeweed, halogeton (*Halogeton glomeratus*), milk vetch (*Astragalus* spp.), and Russian thistle. As in the sagebrush-greasewood community, the rabbitbrush, halogeton, and Russian thistle are indicative of heavy grazing pressure. Indian rice grass is the dominant fall grass, with needle-and-thread grass and Galleta grass represented to a lesser extent.

Cheatgrass dominates the spring growth, with blue mustard (*Chorispora tenella*) and other species in the mustard family the dominant herbs. Other spring species include wild buckwheat, Indian rice grass, squirrel tail grass, stickseed (*Lappula redowskii*), and other species of the borage family; and globe mallow (*Sphaeralcea coccinea*), Galleta grass, Mentzelia, and onion (*Allium* spp.).

Riparian

Cottonwood (*Populus fremontii*) dominate the riparian community along the White River, with saltcedar (*Tamarix pentandra*) the dominant understory shrub. In the riparian area along Evacuation Creek, saltcedar and greasewood are the dominant shrubs. Horsetail (*Equisetum arvense*), rabbitbrush (*Chrysothamnus viscidiflorus* and *Chrysothamnus nauseosus* and wire rush (*Junco balticus*) are also dominant understory plants. Other major shrubs include greasewood, willow (*Salix exigua*), saltbrush (*Atriplex patula*), and big sage. Russian thistle, yellow sweet clover, and snakeweed are the major herbaceous species persisting into the fall. Saltgrass (*Distichlis stricta*) is the dominant grass in the fall, with western wheatgrass (*Agropyron smithii*) and to a lesser extent muhly (*Muhlenbergia asperifolia*) and Kentucky bluegrass the other major grasses persisting into the fall. Spring growth is dominated by cheatgrass. Pepper grass (*Lepidium perfoliatum*) and other species of the mustard family, yellow sweet clover, saltgrass, and western wheatgrass are the major spring plants. Other herbs and grasses occurring in the riparian community include Kochia (*Kochia* spp.), stickseed and other species of the borage family, Kentucky bluegrass, blue mustard, smother weed (*Bassia hyssopifolia*), six weeks fescue (*Festuca Octoflora*), sand bur (*Cenchrus pauciflorus*), snakeweed, the root parasite bastard toad-flex (*Comandra pallida*), ragweed (*Ambrosia psilostachya*), poverty weed (*Iva axillaris*), alkalai sacaton (*Sporobolus airoides*), sagebrush (*Artemisia ludoviciana*), and reed (*Phragmites communis*).

Community Relationships

The major factors determining the distribution, composition, and structure of the plant communities are primarily soils and available water. The cottonwood-dominated riparian community is restricted to the area along the White River where available water is abundant. The juniper community occurs in the higher elevations where soils are very thin and poorly formed.

The sagebrush-greasewood and shadscale communities occur in the areas of relatively low relief, with the sagebrush-greasewood community occurring in the swale areas with relatively deeper soils. The major plant species occurring in both communities are almost identical: however, the dominance of different species distinguishes one community from the other. The shadscale community is dominated by shadscale and big sage, which have shallow root systems relative to greasewood, a co-dominant with shadscale and big sage in the sagebrush-greasewood community.

Of the major shrub species, shadscale and big sage are the dominant species in the sagebrush-greasewood and shadscale communities and are the major shrubs in the juniper community. Black sage is a major shrub in all three communities relative to big sage and shadscale, but it is the dominant understory shrub in the juniper community.

Indian rice grass is a dominant fall grass in all three communities. Galleta grass is a fall co-dominant in the juniper and shadscale communities, and needle-and-thread grass is a fall co-dominant in the shadscale and sagebrush-greasewood communities. In spring the dominant grasses in the juniper community are Indian rice grass and Galleta grass, while cheatgrass is the overwhelmingly dominant grass in the sagebrush-greasewood, shadscale, and riparian communities.

Rabbitbrush is a major herbaceous species in all four communities, and snakeweed is a common major herbaceous species in all but the riparian community. Russian thistle is a major plant in the shadscale, sagebrush-greasewood and riparian communities, but was rare in the juniper community.

The botanical data collected during the baseline studies provide a basis for inferring animal relationships, food chains, watershed yield and erosion potential, and carrying capacity for domestic livestock. Further, the parameters for vegetative cover and plant density have direct usefulness as criteria for revegetation or rehabilitation programs. For instance, knowing that the natural amount of vegetative cover in the juniper type averaged from 7% on steeply sloping hillsides to about 12% on the moderately sloping hillsides would prevent making the mistake during a revegetation program of seeding or planting an area with an excess number of plants and then making an expensive effort (possibly through constant fertilization and

irrigation) to maintain a plant cover in excess of what naturally occurs.

2. PHENOLOGICAL CHARACTERISTICS

a. Methodology

Twenty permanent plots (five plots in each of four vegetation types: riparian, sagebrush-greasewood, shadscale, and juniper) were established in late summer 1974 (Figure IV-2). Phenological observations of the stages of growth and appearance of plant species in the plots were made in September 1974; March, April, May, June, August, and October 1975; and March, May, July, September, and November 1976. Table IV-21 lists the phenological stages observed during the study. The first 22 phenological stages were used for observation during the 1974 and 1975 seasons, and the last five stages were added for the 1976 season. These stages do not include all phenological events, but are adequate to characterize important events in plant development and use by animals. The data for the 1974 and 1975 seasons were reported in the sixth quarterly report and the data for the 1976 season were reported in the ninth quarterly report.

At the conclusion of the 1976 season, data from several species were graphed to show the phenological stages of development of some common plants through that growing season. Two grasses, one forb, and four shrub species were chosen to represent other species with similar phenological development.

b. Summary of Results

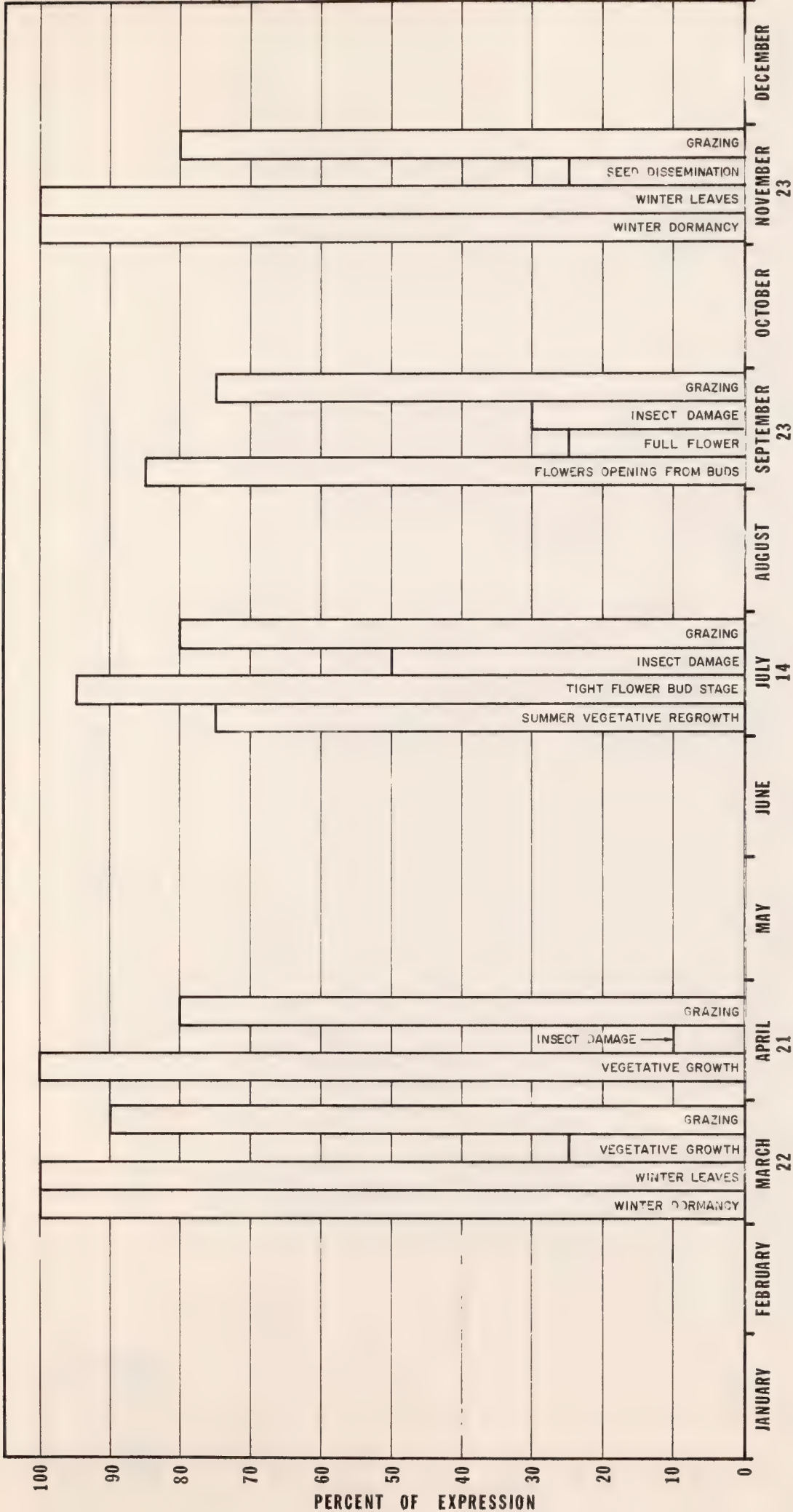
Figures IV-3 through IV-9 are graphs of the phenological development of seven selected species. In interpreting the graphs, it is important to remember that the percentage expressed is based only on species in the plots. Since all species did not occur in all plots for a given vegetation type, the percentage may be based only on one or two key species sampled.

Big Sage

The phenological events for big sage (*Artemisia tridentata*) are graphed on Figure IV-3. This species is a dominant plant, and occurs in all four vegetation types. Since it retains its leaves year round, it is capable of photosynthesis during winter under favorable weather conditions. Leaf bud dormancy

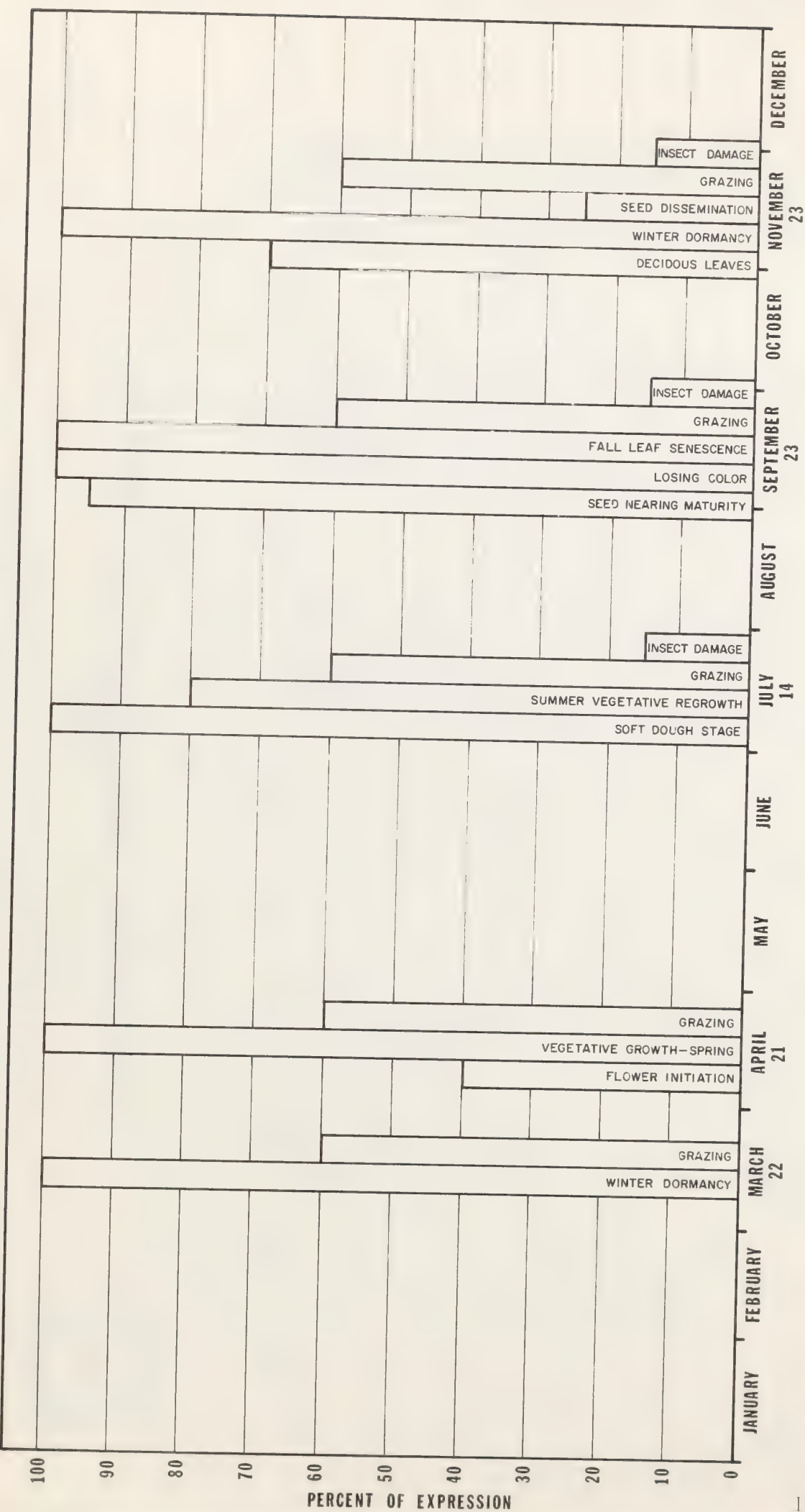
PLANT PHENOLOGY KEY

<u>No.</u>	<u>Phenology Description</u>
1	Winter dormancy
2	Spring growth (Veg.) stem growth
3	Summer leaves
4	Winter leaves
5	Leaves (deciduous)
6	Flower initiation
7	Full flower
8	Seed dissemination complete
9	Summer dormancy
10	Summer vegetative regrowth
11	Insect damage
12	Abnormal senescence
13	Seeds nearing maturity
14	Fall leaf senescence
15	Tight flower bud stage
16	Seed stalk elongation complete
17	Coloration (gain color)
18	Discoloration (losing color)
19	Flowers opening from buds
20	Flowering complete - drying up
21	Soft dough stage
22	Grazing
23	Leaf bud swelling
24	Seed germinating - annuals
25	Spring growth - grass
26	Summer veg. growth
27	Annual forb - growth (veg)



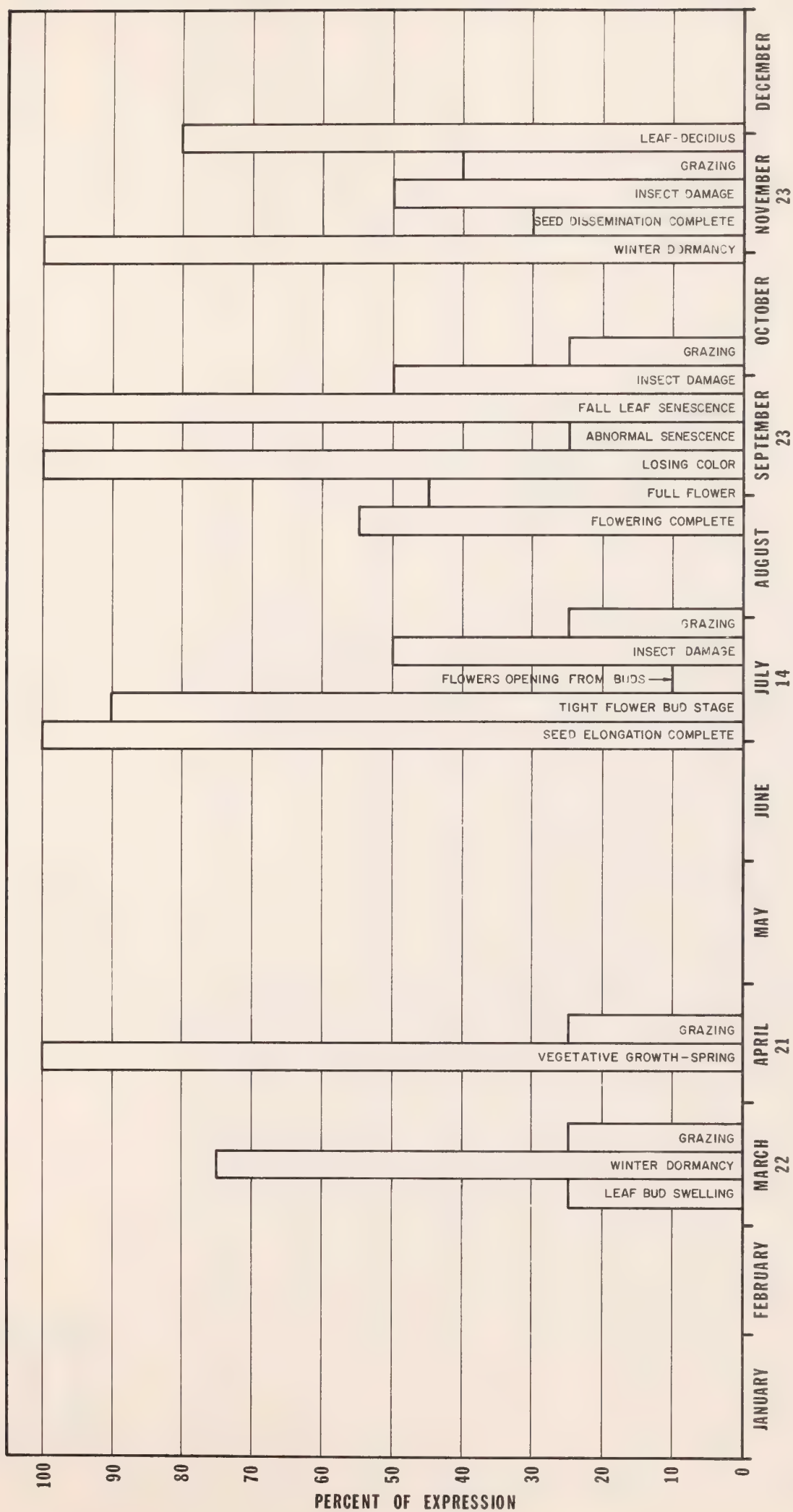
**PHENOLOGICAL GRAPH FOR ARTEMISIA TRIDENTATA
1976**





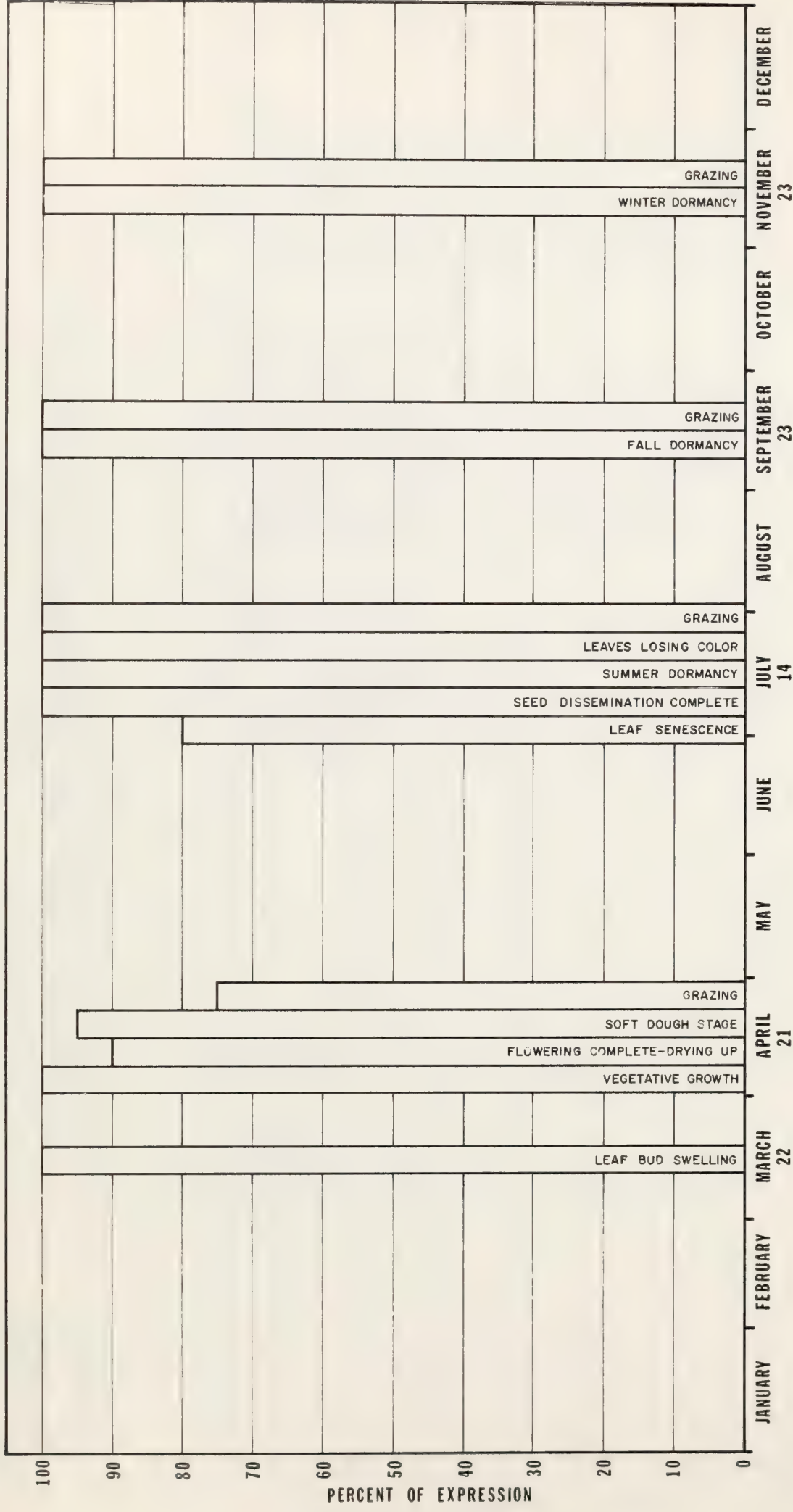
PHENOLOGICAL GRAPH FOR ARTIPLEX CONFERTIFOLIA
1976





PHENOLOGICAL GRAPH FOR CHRYSOTHAMNUS VISCIDIFLORUS **1976**

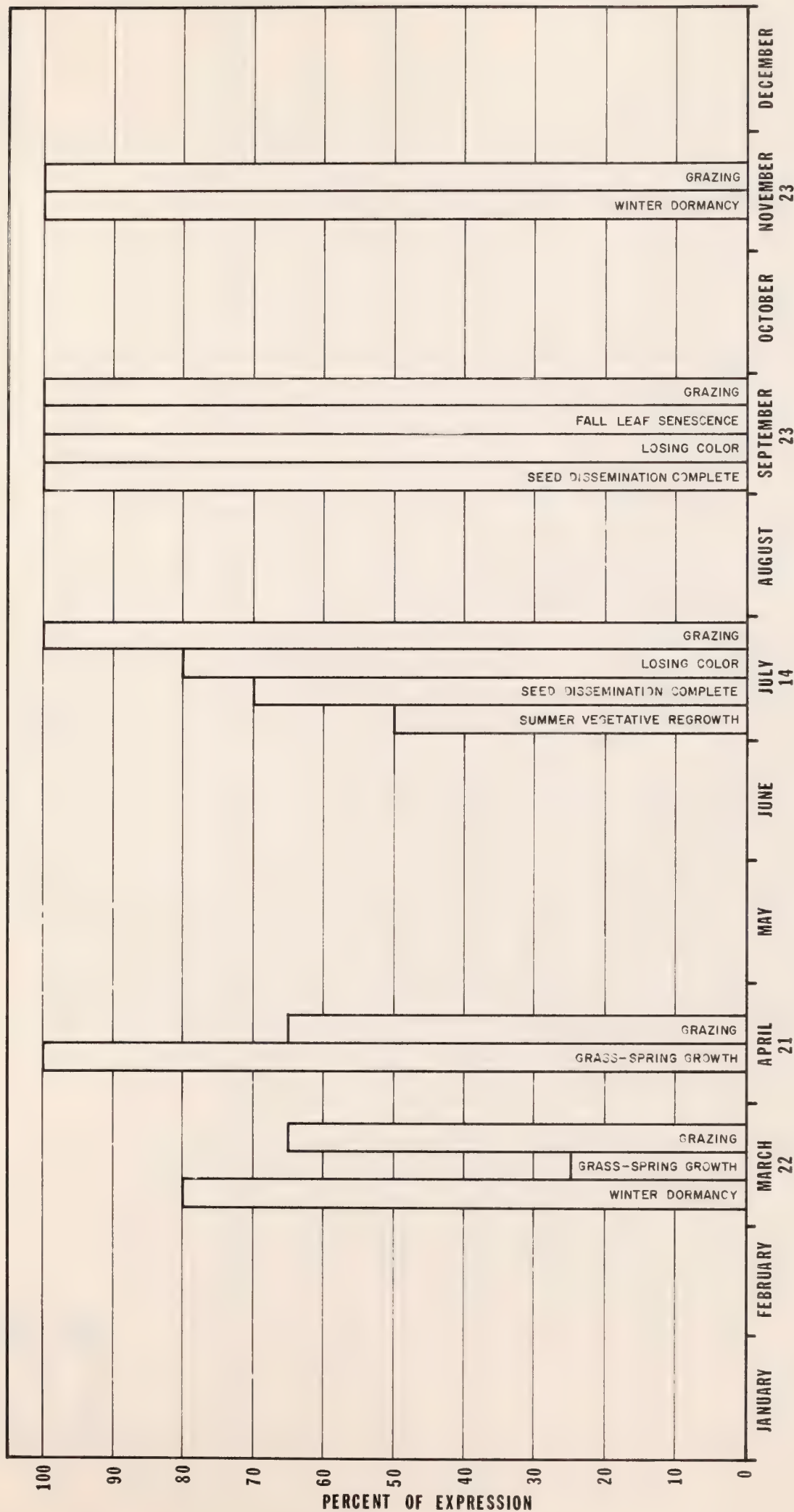




PHENOLOGICAL GRAPH FOR GRAYIA SPINOSA 1976

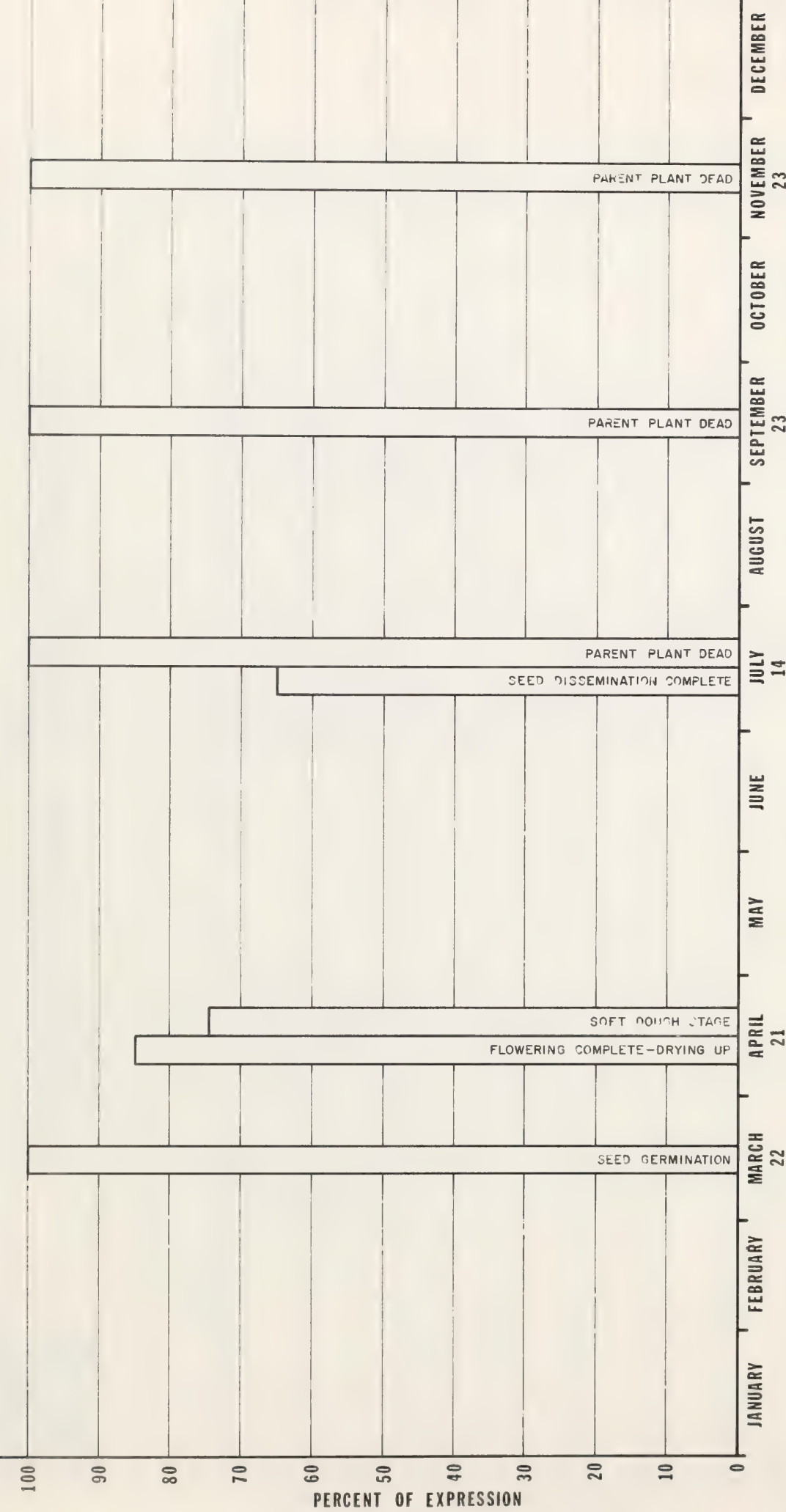
FIGURE IV-6





**PHENOLOGICAL GRAPH FOR ORYZOPSIS HYMENOIDES
1976**

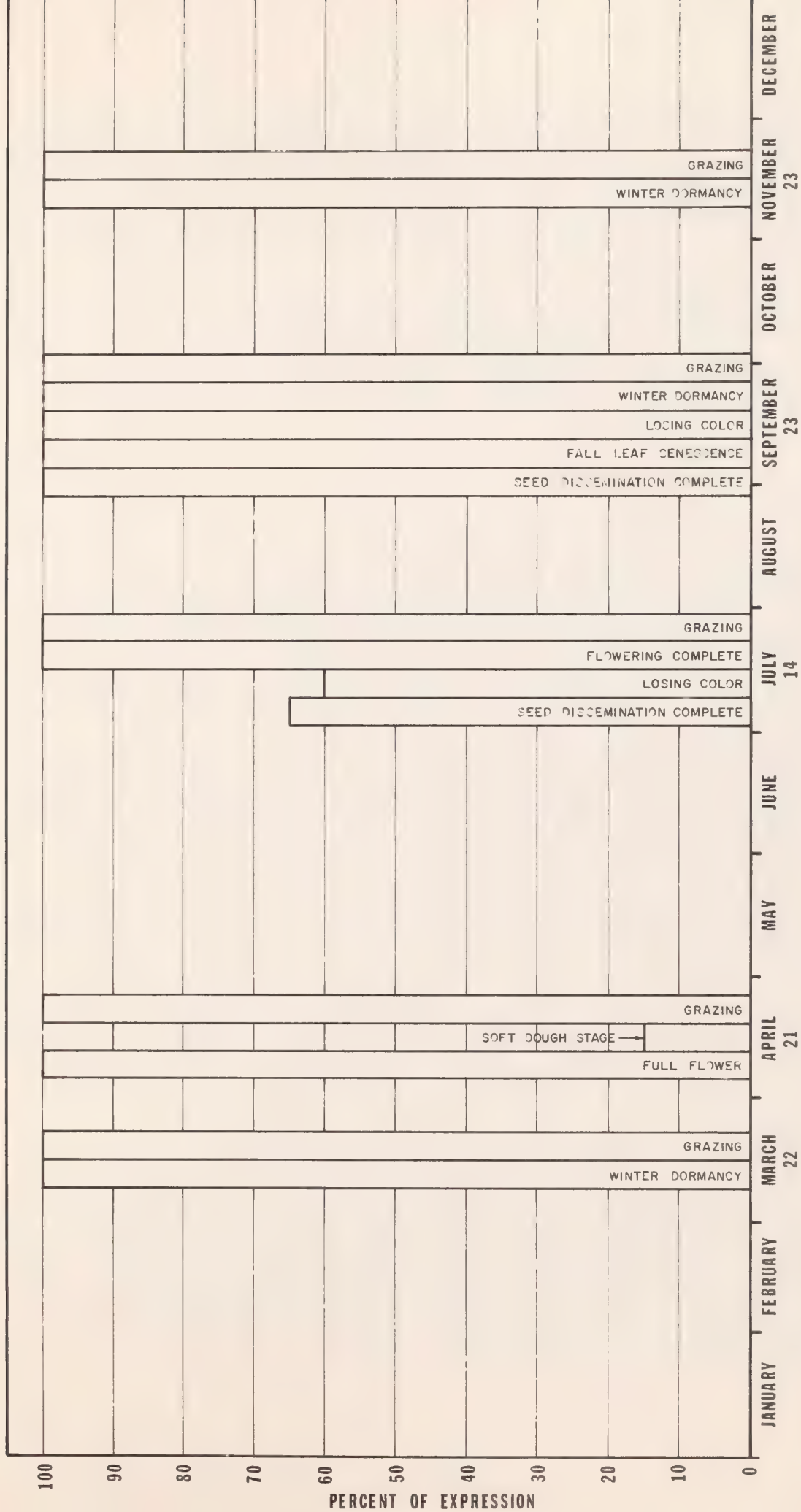




**PHENOLOGICAL GRAPH FOR BROMUS TECTORUM
1976**

FIGURE IV-8





**PHENOLOGICAL GRAPH FOR HEDYSARUM BOREALE
1976**



broke about the end of April, and stem growth occurred at the same time. During July seed stalk elongation was complete and flower buds were present. By September the flowers were opening and the plants were in full flower around the first of October. Flowering continued until the end of October. Seeds were mature by the end of November, and seed dissemination occurred for the next several months.

During the 1976 season, big sage was valuable forage for livestock and wildlife on the tracts, especially during winter. Insects also used this species, especially the flowers and seeds. Black sage (*Artemisia nova*), a closely related species with similar phenological development, was also a valuable forage plant.

Shadscale

Phenological events for shadscale (*Atriplex confertifolia*) are graphed on Figure IV-4. This species is widespread on the tracts, occurring mainly in the sagebrush-greasewood, shadscale, and juniper vegetation types. Other *Atriplex* species on the tracts are four-wing saltbush (*Atriplex canescens*) and saltbush (*Atriplex cuneata*), which are not as widespread as shadscale.

In March shadscale was still in winter dormancy, but by May, leaf expression was complete and stem growth and flower initiation was occurring. By mid-July seeds were in the early, soft-dough stage. Also, some vegetative regrowth was occurring after the plants were grazed. Toward the end of September, seeds were close to maturity and the leaves were losing color and becoming senescent. By November the plants were in winter dormancy, most of the leaves had fallen, and seed dissemination had begun.

Shadscale was used for forage by wildlife and livestock. Rodents girdled the base of stems and branches, and insects consumed the seeds.

Rabbitbrush

Phenological events for rabbitbrush (*Chrysothamnus viscidiflorus*) are graphed on Figure IV-5. This species is found mainly in the juniper and sagebrush-greasewood vegetation types, but can also be found in the riparian and shadscale types. Species of the same genus occurring in the same area are (*Chrysothamnus greenii*) and (*Chrysothamnus nauseosus*). The timing and phenological events of these two species are similar to those of *Chrysothamnus viscidiflorus*.

In March the leaf buds of rabbitbrush were beginning to swell. By May leaf expression was complete and stem elongation was well underway. By July stem elongation was complete and flower buds had formed, with some buds already opened. By mid-September about half the flowering was complete. Leaves were beginning to lose color and become senescent. By November seed dissemination had started and most of the leaves had fallen.

Insects damaged flowers and seeds to a small extent, and grazing was evident. During fall rodents cut many of the small stems near the base and left the stems piled near the plant. The rodents may have been using the stems for a moisture source.

Hop Sage

Phenological stages of hop sage (*Grayia spinosa*) are graphed on Figure IV-6. This species is found mainly in the sagebrush-greasewood vegetation type. Two unrelated horsebrush species, (*Tetradymia nuttallii*) and (*Tetradymia spinosa*), which are associated with hop sage, have similar phenological states that occur at the same time.

Hop sage usually breaks winter dormancy earlier than the other shrub species. Leaf bud swelling began in March, with some leaves starting to expand. By May flowering was over, and the seeds were in the soft-dough stage. By mid-July seed dissemination had started, leaves were beginning senescence, and the plants were going into summer dormancy. This species was browsed to some extent.

Indian Rice Grass

Phenological stages of Indian rice grass (*Oryzopsis hymenoides*), a perennial grass, are graphed on Figure IV-7. The phenology of this grass is representative of that of the other perennial grass species, including beardless wheatgrass (*Agropyron inerme*), needle-and-thread (*Stipa comata*), bluegrass (*Poa secunda*), and squirrel tail grass (*Sitanian hystrix*).

In March most of the plants were still in winter dormancy, but a few were beginning new growth. By late May the plants were in the four-leaf stage. By mid-July the seeds were ripe and being disseminated and the plants were beginning to lose their color. By September seed dissemination was complete and the plants were senescent and by November the plants were dormant. Indian rice grass was heavily grazed by livestock and wildlife, as were the other perennial grasses.

Cheatgrass

Phenological stages of cheatgrass (*Bromus tectorum*) are graphed on Figure IV-8. This species is widespread on the tracts, growing abundantly on disturbed sites. Cheatgrass, an annual grass, is representative of phenological development in the other annual species.

Seed germination, which began in early spring, around March or April, can occur much earlier under the snow. The species matures fast and flowers in late April and May. By July seed dissemination had begun and the plants were beginning to dry. After July, seed dissemination was still occurring, but the parent plants were dead.

Sweet Vetch

Phenological stages of sweet vetch (*Hedysarum boreale*), a perennial forb, are graphed on Figure IV-9. Sweet vetch was selected to illustrate the phenological development of the other perennial forbs on the tracts (that is, milk vetch (*Astragalus* spp.) cryptantha (*Cryptantha* spp.), larkspur (*Delphinium barbeyi*), gillia (*Gillia congesta*), and globe mallo (*Sphaeralcea coccinea*)).

In March sweet vetch was still in winter dormancy. Vegetative growth started in April and flowering had begun by late April or early May. Seed production began during late May and continued until flowering ceased. Seed dissemination started about the end of June and continued until September; however, by mid-July the plants were beginning to lose color and become senescent. By late September the plants were dormant.

Sweet vetch was grazed by livestock and wildlife, as were many of the other perennial forbs.

c. Interpretation and Conclusions

Phenological studies are useful as an adjunct to other studies because they can provide a biological base, rather than a calendar base, for comparison of vegetation from year to year. The sequence of phenological events and appearance of key species in the plant community can serve to reference other biological events.

3. PRODUCTIVITY

a. Methodology

The methods used to determine productivity are described in the FYEBR. Four periods were sampled: September 1974, June 1975, September 1975, and June 1976. The fall sampling was for perennial plant species and a few fall-maturing annuals, such as Russian thistle, and the spring sampling was for annual plant species. Data reported in the FYEBR were reviewed for errors and recalculated to make them parallel with data collected during the second year. Data for each fall sampling period were computed on a 100-plot basis (the total number of plots sampled) rather than on the observed number of plots in which the species occurred, so that the value would represent the productivity of the vegetation type including its open areas.

b. Summary of Results

The results of the spring sampling (production of annual plant species) and fall sampling (perennial and late-summer-maturing annual plants) are presented separately. For easy comparison of the differences between plant production for the two years of the baseline study, data are summarized by sampling period.

Spring 1975, 1976

Annual plant productivity varied considerably among vegetation types (Table IV-22). The production of annual grasses and forbs in the various vegetation types in 1975 ranged from a low of 3.8 g/m² (34 lb/acre) in the juniper type to 590.0 g/m² (5265 lb/acre) in the riparian type. In 1976 the same types produced only 0.25 g/m² (2.2 lb/acre) and 30.57 g/m² (273 lb/acre), respectively. On the average, the production of annual grasses and forbs in 1976 was only 6% of that of 1975.

This much disparity in production is not uncommon between years in which weather conditions are very different. Weather conditions in spring 1975 were very favorable for plant growth, with rainshowers relatively evenly spaced and not too intense during the early months of growth. In contrast, spring 1976 followed a generally cold and dry winter, and the spring rains were too limited to sustain the growth of annual plant species. In June 1976 an intense storm occurred, but as soon as the tract soils were saturated the excess water ran into the White River.

TABLE IV-22

PRODUCTION OF ANNUAL GRASSES AND FORBS IN EACH OF FOUR
VEGETATION TYPES, JUNE 1975 AND 1976.*

	June 1975			
	Sagebrush- Greasewood g/m ²	Juniper g/m ²	Shadscale g/m ²	Riparian g/m ²
Annual Grass				
Mean ($\bar{x}$)	47.77	2.58	173.10	533.25
SD	4.97	.93	17.82	59.95
Frequency ¹	20	5	58	88
Forbs				
Mean ($\bar{x}$)	3.33	1.22	51.20	56.71
SD	4.03	1.14	7.29	11.09
Frequency	11	5	22	89
TOTAL PRODUCTION OF ANNUALS	51.1	3.8	224.3	590.0
	(456 lbs/ac)	(34 lbs/ac)	(2002 lbs/ac)	(5265 lbs/ac)
	June 1976			
	Sagebrush- Greasewood g/m ²	Juniper g/m ²	Shadscale g/m ²	Riparian g/m ²
Annual Grass				
Mean ($\bar{x}$)	11.75	.02	3.70	25.23
SD	14.89	.04	5.43	20.22
Frequency	36	4	38	63
Forbs				
Mean ($\bar{x}$)	9.17	.23	.13	5.34
SD	19.82	.22	.12	5.35
Frequency	20	9	19	45
TOTAL PRODUCTION OF ANNUALS	20.92	.25	3.83	30.57
	(187 lbs/ac)	(2.2 lbs/ac)	(34 lbs/ac)	(273 lbs/ac)

¹Frequency = the number of plots out of a possible 100 plots in which harvests were made.

*Many of the 100 plots per vegetation type did not have annual species present.

Each of the vegetation types showed a large reduction in growth from 1975 to 1976, with the shadscale and the riparian types having the greatest proportional decrease. Whereas in 1975 there was a virtual carpet of grass and forbs in the understory of the riparian type and dense patches of cheatgrass in the shadscale types, in 1976 many areas were bare of any annual vegetation.

Fall 1974, 1975

Perennial plant production, consisting primarily of shrubs in the shadscale and sagebrush-greasewood types and trees in the juniper and riparian types, is a more stable index of site productivity (tables IV-23 and IV-24) than the productivity estimates of the grasses and herbs. The sagebrush-greasewood, juniper, and shadscale types were about one-half to one-third as productive as the riparian type in new perennial growth each year. The cumulative production appears to be greater in the tree types because of the longer life and greater biomass of the trees. Obviously, the greater soil depth and available moisture in the river bottom riparian type are important factors in the comparatively larger production in the riparian areas.

c. Interpretation and Conclusions

The data from the baseline study provide a general assessment of total productivity for two different growing seasons -- fall 1974 and fall 1975 for perennial plants and spring 1975 and spring 1976 for annual species. The greatest variation between the two years were in spring production of annual grasses and forbs. A comparison of the three upland types (Table IV-25) indicates they are similar in productivity. The baseline study was too short to make any reliable calculations concerning potential productivity.

4. ANCILLARY ENVIRONMENTAL FACTORS

During the baseline study a number of conditions and parameters were observed in addition to plant community structure and composition, phenological characteristics, and productivity. Range condition was assessed, soil moisture and temperature were recorded, soil salinity was measured in relation to various sources, patterns of root growth of principal shrubs were observed, and current year's stem growth of sagebrush was measured.

TABLE IV-23

FALL 1974 PRODUCTION OF PERENNIAL SHRUBS, FORBS,
TREES AND LATE-MATURING ANNUALS IN FOUR VEGETATION TYPES

Sagebrush/Greasewood				Juniper			
Species Code	No. Plots Where Observed	Calculated Mean DM g/m ² 100 plots	Sample Size ¹ Req.	Species Code	No. Plots Where Observed	Calculated Mean DM g/m ² 100 plots	Sample Size Req.
AMBPSI	2	.10	2	AGRSMI	3	.15	16
ARTNOV	30	9.10	88	ARTLUD	27	1.94	107
ARTTRI	34	14.10	39	ARTNOV	56	12.15	61
ATRCON	26	3.50	54	ARTTRI	5	1.24	145
CHRVIS	21	3.70	58	ASTRAG	20	1.82	78
CRUCIF	12	.30	15	ATRCON	29	4.46	146
ERIGER	2	.01	2	CHRGRE	7	.49	4
ERIOGO	7	7.10	40	CHRVIS	29	6.32	59
EURLAN	6	.30	43	COMPAL	3	.04	5
GRASPI	19	3.20	81	CRUCIF	21	1.03	75
GUTSAR	24	.90	78	DISSTR	11	1.47	230
HILJAM	11	.20	34	EPHVIR	4	.22	74
KOCVES	5	5.30	25	ERIGER	40	1.24	64
ORYHYM	44	11.40	138	ERIOGO	24	.41	149
SALKAL	34	58.00	288	EUPHOR	48	.53	48
SARVER	31	64.50	211	GUTSAR	55	4.50	21
SITHYS	1	.03	-	HALGLO	1	.12	-
SPHAER	5	.13	53	HILJAM	33	61.40	135
SPOCRY	1	.04	0	HYMSCA	4	.14	40
STICOM	46	3.20	35	JUNOST	16	117.40	49
TETSPI	7	1.55	137	MULASP	1	.06	-
				ORYHYM	53	5.83	300
				PHLHOO	5	.03	68
				POAFEN	1	.02	-
				POASAN	5	.05	93
				SENECO	2	.05	-
				SITHYS	3	.09	16
				SOLRIG	8	.03	17
				STICOM	1	.01	-
				TETSPI	1	.01	-
Total Weighted Mean 186.8 g/m ² (1,667 lbs/acre)				Total Weighted Mean 251.82 g/m ² (2,247 lbs/acre)			

¹Sample size required to sample only that species within 25 percent of the mean at 90 percent confidence level.

TABLE IV-23 (continued)

Shadscale				Riparian			
Species Code	No. Plots Where Observed	Calculated Mean DM g/m ² 100 plots	Sample ¹ Size Req.	Species Code	No. Plots Where Observed	Calculated Mean DM g/m ² 100 plots	Sample ¹ Size Req.
AGRSMI	1	.01	-	AGRSMI	23	3.91	65
ARTNOV	27	15.90	89	AMBSPI	5	.21	87
ARTTRI	40	30.10	63	ARTLUD	1	.04	-
ASTRAG	39	1.21	91	ARTTRI	9	.31	133
ATRCO	89	45.85	51	ASTRAG	1	.02	-
CHRGRE	8	4.05	69	CHEALB	10	.01	-
ERIGER	13	.42	69	CHRNAU	21	40.30	353
ERIOGO	3	.11	4	CHRVIS	44	85.40	250
EUPHOR	2	.03	2	CLELUT	1	.01	0
ERULAN	4	.09	49	DISSTR	40	16.40	320
GUTSAR	36	2.48	107	EQUARV	6	.03	113
HALGLO	24	.77	70	GUTSAR	3	2.00	61
HILJAM	9	2.79	73	IVAAXI	11	.10	60
KOCVES	3	.43	2	JUNBAL	1	.02	-
ORYHYM	15	1.04	111	KOCSCO	4	2.69	24
SALKAL	10	1.61	143	MELOFF	2	.03	12
SARVER	18	16.85	47	PHRCOM	1	.22	-
SITHYS	4	1.35	28	POAFEN	4	.10	30
SPHCOC	5	.12	42	PAPFRE	8	181.00	103
STICOM	1	.07	-	SALEXI	11	4.49	165
TETSPI	14	4.65	200	SALKAL	15	2.67	94
				SARVER	8	53.60	85
				SISALT	2	.09	79
				SPOAIR	6	.91	47
				TAMPEN	14	193.70	121
Total Weighted Mean 130.29 g/m ² (1,163 lbs/acre)				Total Weighted Mean 588.30 g/m ² (5,250 lbs/acre)			

TABLE IV-24

FALL 1975 PRODUCTION OF PERENNIAL SHRUBS, FORBS,
TREES, AND LATE-MATURING ANNUALS IN FOUR VEGETATION TYPES

Sagebrush/Greasewood				Juniper			
Species Code	No. Plots Where Observed	Calculated Mean DM g/m ² 100 plots	Sample Size ¹ Req.	Species Code	No. Plots Where Observed	Calculated Mean DM g/m ² 100 plots	Sample Size Req.
ARTSPI	7	.45	42.3	ARTNOV	42	47.06	66.2
ARTTRI	64	42.40	37.8	ARTTRI	18	1.33	69.7
ASTRAG	2	.25	70.0	ASTRAG	6	2.03	48.4
ATRCON	94	52.67	24.0	ATRCON	19	8.24	53.6
ATRPOW	1	.07	-	CHRGRE	6	.14	122.7
CHRGRE	13	28.24	1.0	CHRVIS	9	.86	35.5
ERIEFF	15	1.50	73.8	CRUCIF	6	.01	15.2
ERIENG	24	.18	81.5	CRYPTA	33	.32	21.7
ERIOGO	3	.01	36.0	EPHVIR	5	.09	42.8
EURLAN	4	.07	4.8	ERIGER	7	.04	23.8
GRASPI	3	.65	36.4	ERIMOC	23	.19	131.7
GUTSAR	37	22.05	17.3	ERIOGO	10	.04	21.2
HALGLO	4	.40	505.5	ERIOVA	10	.03	24.0
HILJAM	9	1.50	216.4	ERIVIS	4	.01	43.7
OPUNTI	14	.98	41.6	EUPFEN	22	.15	31.0
ORYHYM	28	1.95	52.6	EUPHOR	7	.06	15.2
SARVER	18	4.08	834.1	GRASPI	1	.04	-
SITHYS	2	.03	71.1	GUTSAR	51	4.96	53.0
SPHCOC	14	.16	15.9	HALGLO	2	.03	84.9
SPHPAR	2	.01	36.9	HEDBOR	5	.25	27.5
SPOAIR	2	.41	21.6	HILJAM	12	1.79	218.3
SPOCRY	8	.49	35.1	JUNOST	56	57.58	77.3
STICOM	10	.35	95.3	KOCAME	1	.01	-
SUZSUF	5	.22	104.8	LEPPUN	3	.01	7.5
TETNUT	2	1.49	74.9	OPUPOL	1	.02	26.3
TETSPI	15	3.71	1.7	ORYHYM	18	5.59	-
				PETPUM	16	.38	63.4
				PHLHOO	13	.15	76.2
				PINEDU	2	1.21	82.3
				POASAN	6	.41	22.5
				RANTES	2	.01	15.9
				SITHYS	2	.01	15.9
				STICOM	20	.10	54.2
Total Weighted Mean 164.26 g/m ² (1,466 lbs/acre)				Total Weighted Mean 133.15 g/m ² (1,188 lbs/acre)			

¹No. of samples required to estimate within 25 percent of the true mean with a 90 percent level of statistical confidence.

TABLE IV-24
(continued)

Shadscale				Riparian			
Species Code	No. Plots Where Observed	Calculated Mean ² DM g/m ² 100 plots	Sample ¹ Size Req.	Species Code	No. Plots Where Observed	Calculated Mean ² DM g/m ² 100 plots	Sample ¹ Size Req.
AMBSPI	1	.02	-	AGRSMI	24	6.20	278.0
ARTNOV	22	9.33	69.6	AMBPSI	4	.19	120.0
ARTSPI	5	1.73	71.7	ARTLUD	1	.01	-
ARTTRI	47	32.59	29.6	ARTTRI	6	1.33	30.2
ASTRAG	5	.04	73.6	ATRCAN	3	1.01	73.8
ATRCON	38	23.84	25.7	ATRCON	1	.03	-
CHRGRE	38	12.98	57.5	ATRPAT	21	.89	27.6
EUPHOR	2	.07	86.6	ATRPOW	1	.02	-
ERIGER	6	.06	40.3	CHRNAU	27	15.45	175.7
ERIOGO	13	.30	28.5	CHRVIS	46	26.19	76.8
EURLAN	8	.55	34.1	CIRSIU	2	.32	-
GRASPI	29	11.07	33.6	CLELUT	2	.15	-
GUTSAR	14	1.03	55.2	CLESER	2	.10	-
HILJAM	10	1.16	27.5	COMPAL	11	2.00	67.3
HYMENO	2	.04	9.6	DISSPI	48	16.86	74.6
LEPMON	3	.37	-	EMLOFF	1	.01	-
OPUNTI	2	.05	-	EQUARV	6	4.39	107.0
ORYHYM	49	8.19	36.5	ERIENG	3	.02	22.1
SARVER	40	12.75	69.0	GRISQU	1	.01	-
SITHYS	6	.23	30.6	JUNBAL	5	.22	32.7
SPHCOC	4	.18	94.3	MELOFF	25	.79	53.3
SPOCRY	3	.12	26.0	MULASP	2	5.25	-
STICOM	39	9.52	47.0	OPUNTI	1	.01	-
SUAEDA	3	3.33	1.5	PHRCON	3	.72	31.0
TETSPI	6	1.06	27.2	POAPRA	5	3.65	34.0
				POPFRE	31	161.96	27.7
				RHUTRI	1	.01	-
				ROSWOO	1	.08	-
				SALEXI	13	15.35	89.1
				SALKAL	16	3.68	78.2
				SARVER	12	21.02	93.2
				SPOAIR	3	1.01	61.7
				TAMPEN	13	14.30	29.4
				TAROFF	1	.32	-
Total Weighted Mean 130.61 g/m ² (1,166 lbs/acre)				Total Weighted Mean 303.55 g/m ² (2,709 lbs/acre)			

¹No. of samples required to estimate within 25 percent of the true mean with a 90 percent level of statistical confidence

TABLE IV-25 GENERAL COMPARISON OF PRODUCTION OF PERENNIAL SHRUBS,
TREES, FORBS AND LATE MATURING ANNUALS IN FOUR VEGETATION
TYPES, SEPTEMBER-1974 AND SEPTEMBER 1975.

Calculated Mean Production on 100 Plot Basis				
	1974		1975	
	g/m ²	(lbs/acre)	g/m ²	(lbs/acre)
Sagebrush- Greasewood	186.8	(1,667)	164.3	(1,466)
Juniper	251.8	(2,247)	133.2	(1,189)
Shadscale	130.3	(1,163)	130.6	(1,165)
Riparian	588.3	(5,250)	303.5	(2,708)

a. Methodology

Range Condition

Range condition, a calculated value judgment, was determined by a specialist in range condition analysis after two days of field reconnaissance over each of the vegetation types. Range condition was appraised using the four-factor system developed by the U.S. Forest Service (1969), which employs a rating for vegetal composition, plant production, ground cover, and soil erosion.

Soil Temperature and Soil Moisture

Soil moisture and soil temperature data were recorded from locations immediately adjacent to the 20 phenological observation locations (5 representative sites in each of the 4 vegetation types). Soil psychrometers capable of measuring temperature were placed at depths of 45 cm (18 in.), or at bedrock in sites where soils were shallower than 45 cm. Soil surface temperature was measured with mercury thermometers by inserting the bulb just under the surface for ten minutes and then making a reading.

Soil Salinity and pH

Soil salinity was measured by collecting eight soil samples from several locations of varying degrees of salinity, such as at the base of a nahcolite cliff overlooking Evacuation Creek, and in dry sand on the banks of the creek, moist sand, and soil under the canopy of a greasewood shrub. The pH was determined from a saturated paste, and both pH and electrical conductivity were determined for the saturated extract from each soil. These measurements are reported in the FYEBR for comparison with samples of processed shale, raw shale, and topsoil for which pH and EC were determined in the revegetation research program.

Root Growth

Patterns of root growth were observed from key plant species excavated by shovel and metal probe in summer 1975.

Sagebrush Stem Growth

Current year's growth of sagebrush stems (twigs) was measured in October 1975 and October 1976 to evaluate stem growth as an index of seasonal productivity and possible use in measuring any impacts of industrial development on plant growth. From two locations in the vicinity of Section 22 and four locations that were 2 km to 3 km from Section 22, twenty sagebrush plants were randomly selected along a 100-m transect at each site. Twenty of the largest non-flowering stems on each plant were measured from the top to the bud-scale scar of the previous year's growth. A total of 2400 stems were recorded.

b. Summary of Results

Range Conditions

Dr. Don Dwyer's evaluation of range conditions during June 1976 is as follows:

Tracts U-a and U-b have a history of abuse from sheep grazing. Tract U-b, particularly, has served as a driveway for sheep herds moving from winter to spring and summer range since before 1900. There is ecological evidence that recent grazing is much less abusive than it has been, but there is little indication that the range has improved.

The tracts have been grazed for decades, primarily as winter sheep range from about October through shearing time in late April and early May. This type of grazing does little if any damage to the range when forage and the number of sheep are properly balanced; however, on the tracts the uncontrolled grazing practices of the past have caused a decline in the number of desirable shrubs and grasses and an increase in less desirable shrubs such as sagebrush and greasewood. Especially noticeable is the scarcity of perennial grass plants and grass species.

Range conditions were assessed in the four major vegetation types on the tracts -- sagebrush-greasewood, shadscale, juniper, and riparian. Sagebrush-greasewood, which constitutes an estimated 25% of tracts, occurs on the heavier soils at lower elevations and in the drainageways around the shale hills. Sagebrush is the dominant plant, with greasewood increasing in importance on the heavier soils. This plant community is open, with very little herbaceous understory vegetation. Most of the sagebrush plants are hedged from sheep grazing. There are very few plants in the community that do not show signs

of recent grazing. There are very few perennial grass plants present. Occasionally squirrel tail grass can be found within the protective canopy of sagebrush or other shrubs. On rare occasions Indian rice grass is seen in a similar location.

Sheep trails are evident throughout this type. The soil in and near the trails is pulverized, and erosion is widespread and active. There is no accumulated litter except deep within sagebrush canopies. Very little reproduction was observed from desirable plants in this vegetation type, although some sagebrush reproduction was apparent.

Foliar cover is low throughout this type, and much of the soil surface is exposed. Overall productivity is relatively low as a result of the generally low state of vigor exhibited by the plants. Over the tracts this vegetation type is commonly high poor to low fair in range condition. The past two spring seasons with favorable climatic conditions have improved conditions somewhat.

Shadscale is widespread throughout the tracts, making up 35% to 40% of the area on soils with loose shale outcroppings. Shadscale is the dominant species, ranging from a pure stand on hot, dry south-and west-facing slopes to about an even mix with sagebrush as the soil changes from shale outcropping to a finer texture.

Shadscale has survived the past decades of heavy grazing, even though it is a plant preferred by sheep for winter grazing. In this type shadscale has declined in abundance, despite its tenacity and sagebrush has increased. Both shadscale and sagebrush are heavily grazed. Other shrubs found in this vegetation type are rabbitbrush (*Chrysothamnus viscidiflorus* and *Chrysothamnus greenii*), and in pockets of heavier soil, greasewood and horsebrush.

Grasses are rare, but squirrel tail grass, Indian rice grass, beardless wheatgrass, and needle-and-thread grass can be found under the protection of shrubs. On areas where outwashes occur on lower elevations, sand dropseed (*Sporobolus cryptandrus*) and Galleta grass are on finer textured soils. Very few forbs were seen.

The ever-present sheep trails are further evidence of the grazing pressure to this plant community. The ridgetops of the shadscale-sagebrush type are favorite sheep bedding grounds, and thus have even greater pressures from sheep activities.

The shale-exposed surface protects the community from excessive erosion. Any soil that may have been present on the hillsides in decades past has long since vanished.

Throughout this type many dead shadscale and some, but fewer, dead sagebrush plants were observed. It is assumed the plants have succumbed as a result of excessive grazing and its attendant causes, such as reduced plant resistance to disease and insect damage.

Very little bud sage (*Artemisia spinescens*) was present, and no four-wing saltbush was seen. Both of these plants should be common in this vegetation type.

The range condition of the shadscale-sagebrush type is mid to high poor. The trend is static to slightly upward, as evidenced by the numerous shadscale and sagebrush seedlings, but there is little else to substantiate an upward trend in range condition.

The juniper plant community occurs on sandstone outcrops at the upper elevations on about 35% to 40% of the tracts, usually above 1670 m (5500 ft). On the tracts this type is not a good representative of this important western vegetative type. There are very few pinyon pines, probably less than 5% of the total tree canopy. The juniper trees have a distorted growth habit, indicating their rather marginal existence in the type. There is very little understory vegetation, and erosion is widespread and active. Grasses and forbs are almost nonexistent, although Galleta grass was found occasionally on the heavier soils. At the lower elevations, sagebrush mingles with juniper on the finer textured soils in the draws and bottomlands. *Artemisia nova* and *Artemisia parryi* are in some areas with the juniper, primarily in the openings. The juniper trees have well-defined browse lines at the convenient grazing height for sheep.

There can be little doubt that this vegetation type is generally in poor to very poor range condition. The trend is static to downward; in fact, in most of the locations observed the vegetation is completely deteriorated.

The riparian vegetation type follows the main water courses on the tracts. This type contains the fewest acres of any of the major vegetation types (about 3% of the tract area), although it is the most complex and diverse. This type is the most productive on the tracts and appears to be fairly stable. Its condition and status depend largely on the fluctuating water levels of the rivers and tributaries.

The range condition is high fair and the trend is stable. There is much indication of considerable activity from man and animals.

Soil Temperature and Soil Moisture

Soil temperature and soil moisture data were collected to compare these parameters between the four vegetation types. Figures IV-10 through IV-13 show the three parameters for each vegetation type. Each point on the graph is the mean average of the five permanent plots in each vegetation type.

Figure IV-10 shows the soil surface temperatures for the four vegetation types. Soil surface temperature fluctuates with incident solar radiation. The surface is considerably cooler in the late afternoon. Thus, the soil surface temperature varies from place to place, depending on time of day, cloud cover, and plant canopy over the surface. During the late spring the temperature can vary between 13°C and 35°C (55°F and 95°F). During the summer the surface temperature can become as high as 60°C (140°F), and during late fall the surface temperature averages between -5°C to 10°C (23°F to 50°F).

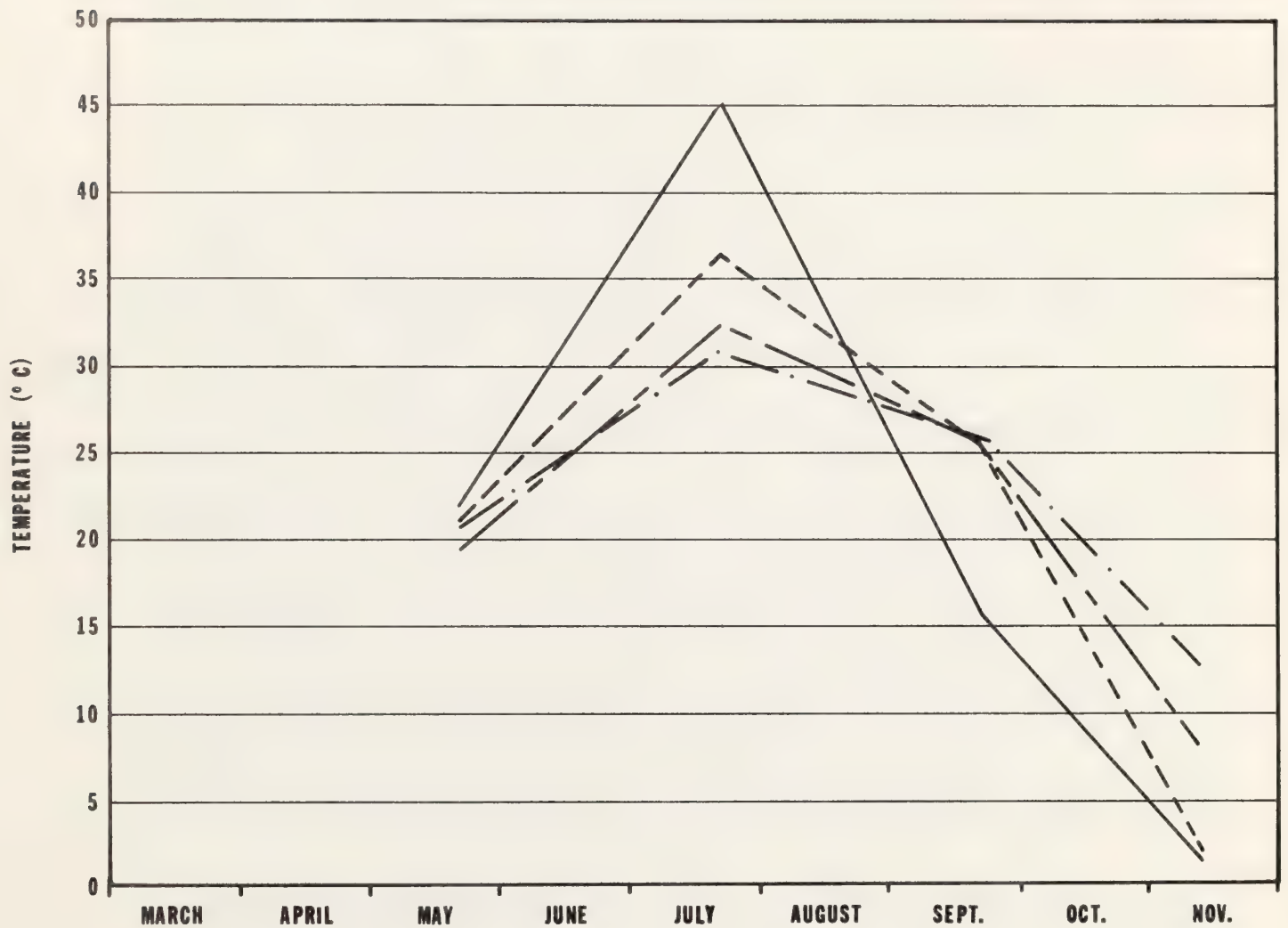
The soil temperature at 30 cm (11.8 in.) does not fluctuate as much as the surface soil temperature because the soil is efficient in dampening the penetration of solar radiation through the soil. Thus, there is very little daily temperature fluctuation at 30 cm, but a seasonal temperature change does occur, as indicated by Figure IV-II.

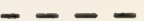
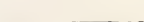
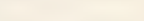
Both daily and yearly soil temperature and soil surface temperature variations are functions of the particular soil type. They do not change that much between seasons unless a significant change occurs in the factors which affect the soil temperature such as soil texture, moisture, plant cover, etc.

Soil moisture fluctuates from year to year depending on the yearly precipitation. Figures IV-12 and IV-13 show the difference in soil moisture potentials on the tracts for 1975 and 1976. The soil moisture potential was higher in 1975 than in 1976 because of the many low-intensity showers in 1975.

Soil Salinity and pH

Measurements of soil salinity and pH of soils sampled in summer 1975 are reported in the FYEBR. To provide a perspective for these values, additional data from the revegetation studies are recorded on Table IV-26. The highest electrical conductivity measurements (EC) in the soil samples taken from various locations adjacent to Evacuation Creek ranged from less than 1 mmhos/cm from a cheatgrass site 3m² above the stream bed to 44 mmhos/cm and more than 50 mmhos/cm² in saltgrass microsites just above the creek and in a seep area at the base of the cliff where evaporation had concentrated the salts. In contrast, an EC of 1 mmhos/cm



SAGEBRUSH/GREASEWOOD 
 JUNIPER 
 SHADSCALE 
 RIPARIAN 

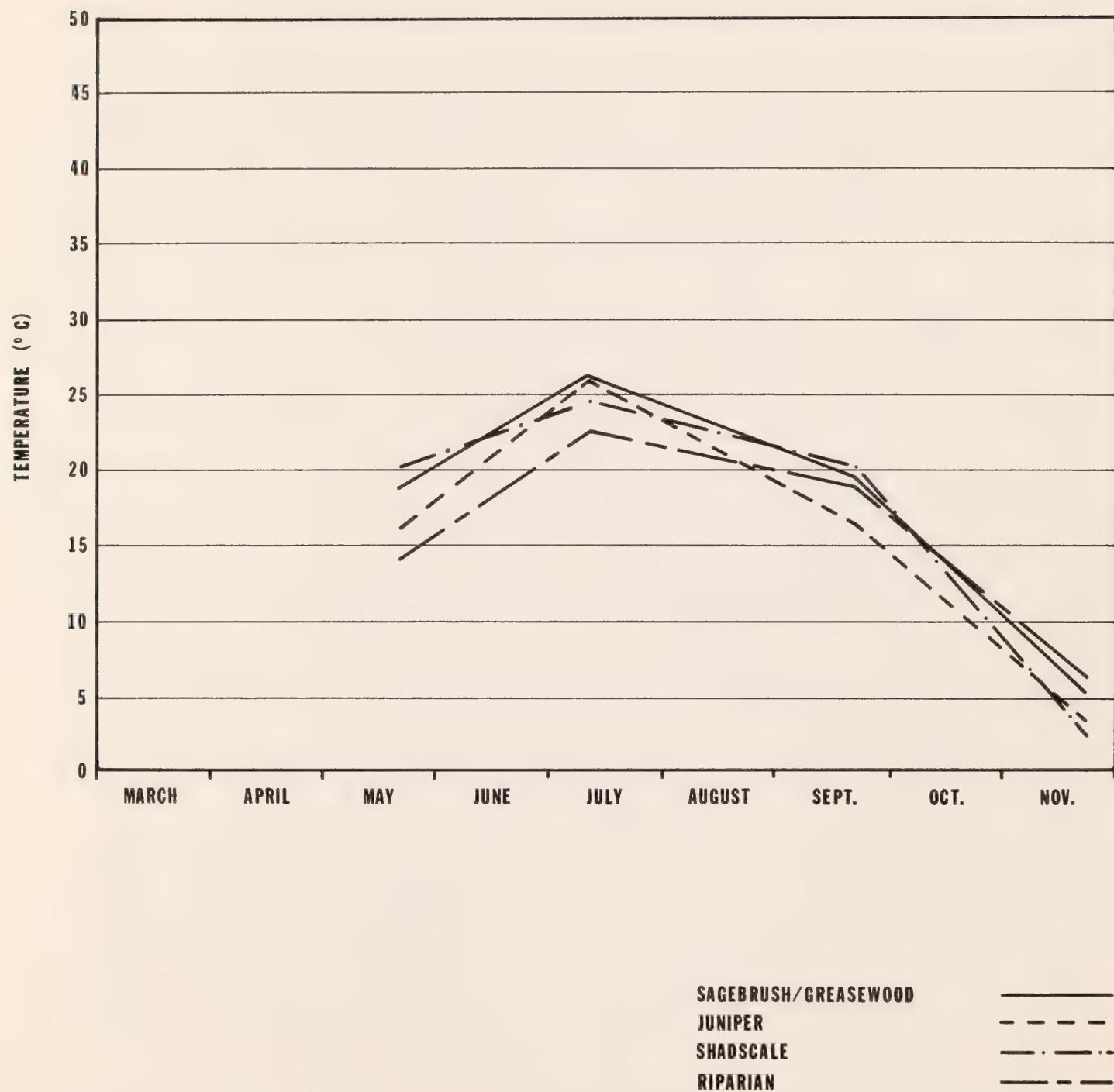
SOIL SURFACE TEMPERATURE

1976

IV-66

FIGURE IV-10





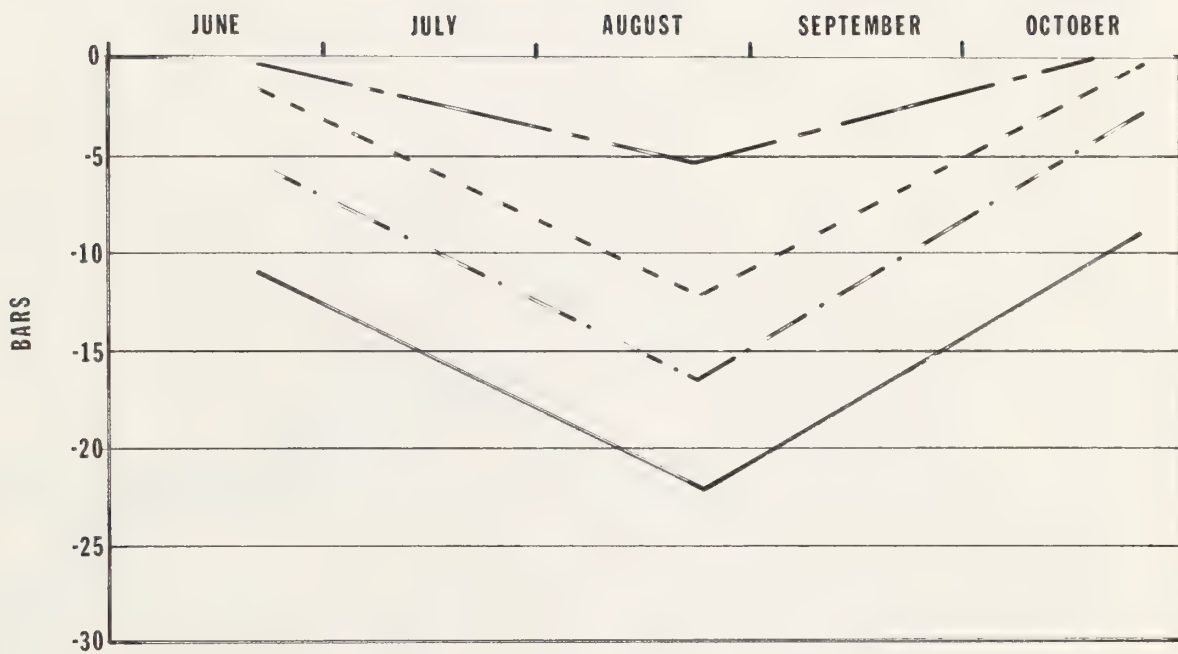
SOIL TEMPERATURE AT 30 CM. DEPTH

1976

IV-67

FIGURE IV-11





SAGEBRUSH/GREASEWOOD

JUNIPER

SHADSCALE

RIPARIAN



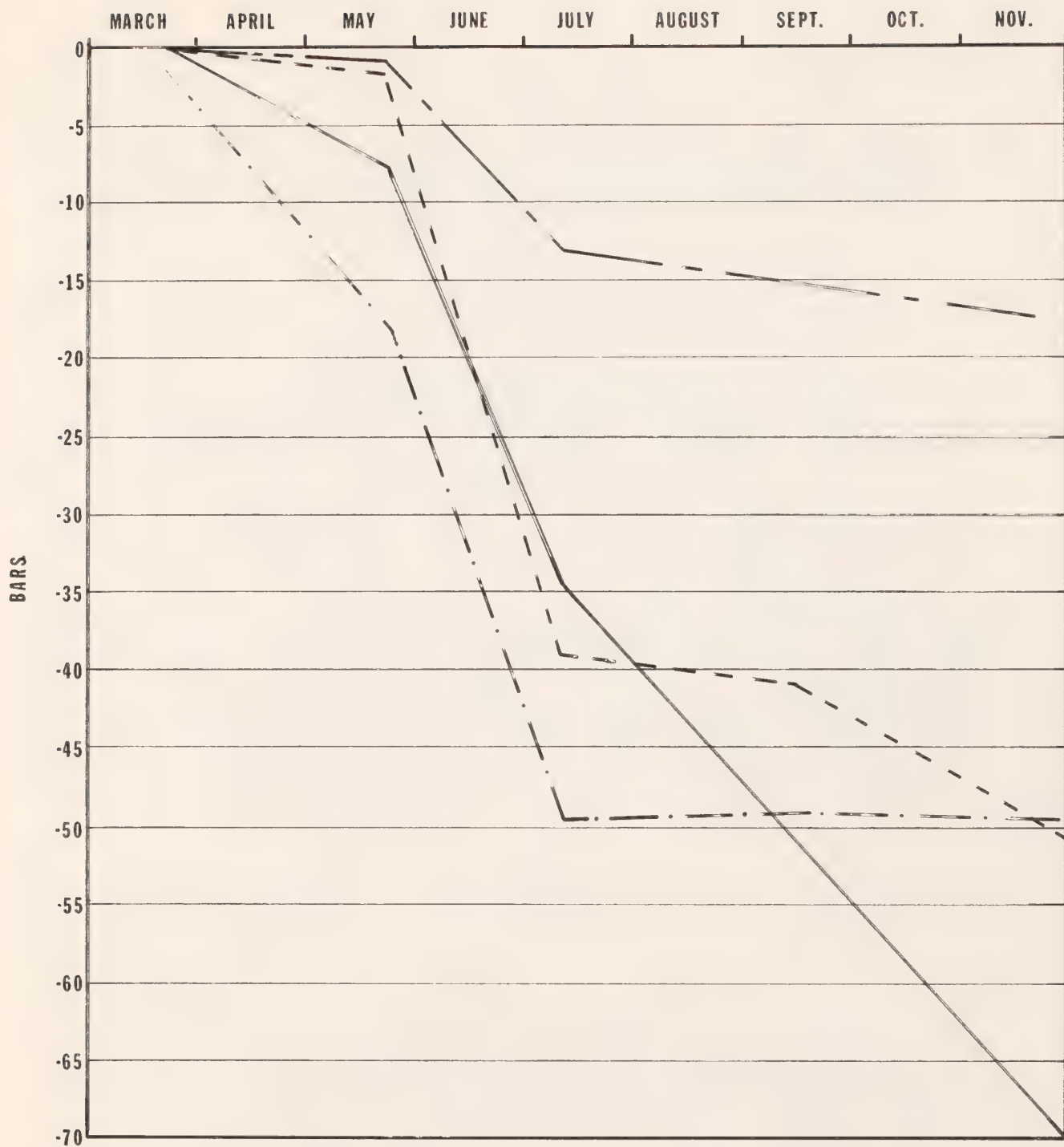
SOIL MOISTURE POTENTIAL

1975

IV-68

FIGURE IV-12





SAGEBRUSH/GREASEWOOD

JUNIPER

SHADSCALE

RIPARIAN

SOIL MOISTURE POTENTIAL

1976

IV-69

FIGURE IV-13



TABLE IV-26

ANALYSIS OF SOIL AND OIL SHALE SAMPLES FOR REHABILITATION STUDIES.

	Extractable Ammonium Acetate cations meq/100g					
	Na+	Ca++	Mg++	% N	pH	EC (mmhos/cm ²)
Topsoil from Section 6 North of White River	5.3	35.6	2.7	0.11	7.6	1-2
Processed shale from Hells Hole Canyon	1.1	25.8	0.9	0.37	7.7	3.2
Paraho-processed Colorado shale	6.0	36.3	15.2	0.18	9.0	18

to 2 mmhos/cm is common in the topsoil of the revegetation research site, and an EC of 18 mmhos/cm was found in one sample of Paraho-processed shale. According to Schmehl and McCaslin (1973), TOSCO-processed shale may have an EC ranging from 9 mmhos/cm to 26 mmhos/cm. Values for pH are similar for saline soil and processed shale. Soil pH's of 8.4 to 9.0 compared closely with 9.0 for Paraho-processed shale.

Root Growth

Studies of root-growth patterns were conducted in 1975 and continually supplemented by field observations in 1976, especially in relation to revegetation research. There are no significant new data to add to that reported in the FYEBR.

Sagebrush Stem Growth

In the study of current year's stem growth, sagebrush varied from plant to plant and from site to site (tables IV-27 and IV-28). The over all sagebrush leader (stem) growth was less in 1976, at 5.9 cm (2.3 in.) than it was in 1975 at 7.0 cm (2.8 in.), reflecting the less favorable timing and intensity of precipitation in the second year of the baseline study. Also, the data seemed to vary more during the 1975 season than during the 1976 season.

c. Interpretation and Conclusions

Range Condition

The range condition assessment has indicated that the tracts have been seriously impacted by decades of sheep grazing. The over all range condition of the tracts is poor based on ecological evidence observed at numerous locations. The only vegetation type in higher range condition is the riparian type, which is in fair condition.

The vegetation types are marked by sharp boundaries caused by soil-type changes and slope exposure. The climate of the area is harsh, with hot, dry, windy summers and cold, snowy winters. The plant mix is mostly cold desert species and a few warm season plants.

Probably due to the generally favorable climatic conditions of the past two years, there are indications that the trend in range conditions is static to slightly upward; however, this

TABLE IV-27

MEAN SAGEBRUSH LEADER LENGTH FOR 1975 AT SIX SELECTED SITES.
Length in cm and one standard deviation are reported. Means
are from 10 observations.

Plant No.	Site Number (see Figure IV-2 for location)											
	1		2		3		4		5		6	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
1	8.43	3.122	6.92	1.694	7.37	2.001	7.25	1.492	10.33	2.751	3.91	0.812
2	3.78	1.500	6.71	2.106	7.82	2.208	4.52	0.893	9.22	1.711	4.52	1.592
3	7.17	4.586	5.44	1.969	6.28	1.634	5.49	1.130	5.12	1.209	3.61	0.880
4	8.28	1.253	6.41	2.221	10.17	3.317	6.57	1.738	6.76	1.486	4.15	1.214
5	7.22	2.624	7.59	1.948	8.01	2.924	5.23	1.218	5.39	1.462	7.16	1.019
6	3.80	1.789	9.16	2.672	11.83	2.293	5.49	1.037	8.21	1.693	6.45	1.474
7	7.29	1.891	7.43	2.486	11.13	3.711	5.86	1.136	6.34	1.786	7.77	1.649
8	6.65	1.953	8.45	1.473	9.29	2.826	3.75	0.958	5.08	2.047	5.79	1.429
9	5.97	1.374	6.33	2.504	8.49	1.446	6.51	1.316	7.77	1.991	6.75	1.950
10	12.41	4.386	7.89	3.062	11.63	3.760	4.72	1.904	7.08	0.985	3.78	0.859
11	9.79	2.440	5.96	2.262	11.36	4.789	5.94	1.857	6.81	2.008	5.16	1.530
12	7.68	4.216	8.14	2.651	8.39	1.976	4.11	0.862	8.75	1.034	4.07	1.280
13	11.08	2.217	7.56	1.711	9.87	2.331	7.56	1.938	6.67	1.446	3.59	0.703
14	8.92	1.526	6.49	1.417	12.20	2.208	5.81	1.061	7.39	1.632	4.20	0.888
15	6.71	1.554	7.94	2.422	7.53	0.902	6.61	1.259	7.68	1.987	6.93	1.835
16	4.96	1.544	6.97	2.896	11.12	3.640	4.25	1.002	6.86	1.423	7.69	2.392
17	7.06	1.836	7.45	1.952	12.60	2.155	6.18	1.205	6.55	1.967	6.64	1.813
18	5.83	3.117	4.04	1.244	7.98	2.103	5.71	1.311	6.99	2.016	7.07	1.967
19	7.14	1.029	7.19	2.656	10.71	3.671	4.73	0.966	7.68	1.963	4.32	1.834
20	7.81	3.220	5.08	1.201	10.04	2.492	5.74	1.550	6.35	2.048	3.76	1.208
Site Mean, S.D.	7.399	2.135	6.958	1.212	9.691	1.859	5.602	1.033	7.151	1.313	5.366	1.530
Overall Mean, S.D.	7.028	1.552										

TABLE IV-28

MEAN SAGEBRUSH STEM LENGTH FOR 1976 AT SIX SELECTED SITES.
LENGTH IN CM AND STANDARD DEVIATION ARE REPORTED. MEANS ARE
FROM 20 OBSERVATIONS.

Plant No.	Site Number (See Figure IV-2 for Location)											
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
1	4.6	0.9	3.7	0.7	6.4	1.1	6.0	0.9	5.5	1.5	3.8	0.6
2	5.9	1.2	5.4	1.4	6.1	0.9	5.4	1.0	6.0	1.3	4.3	0.8
3	5.1	1.1	4.2	0.7	5.3	0.9	4.4	0.6	8.6	1.7	4.3	0.6
4	5.9	1.1	6.4	1.1	8.5	1.1	5.2	0.9	7.7	1.4	4.9	1.2
5	5.3	1.1	8.8	1.1	7.2	1.0	5.0	0.9	6.5	1.3	5.5	1.1
6	5.1	0.8	6.7	1.8	6.8	0.9	6.8	1.8	4.1	0.7	6.6	1.7
7	5.8	1.3	6.5	1.5	8.0	1.4	6.0	0.8	4.5	0.7	5.8	1.0
8	6.6	1.3	5.5	0.9	6.6	1.4	4.8	0.8	4.2	0.7	6.2	1.1
9	5.1	1.5	5.8	1.2	8.4	1.5	6.6	1.5	4.9	0.8	6.6	1.5
10	6.7	1.2	6.8	1.1	6.5	0.9	5.0	0.7	5.7	0.9	4.8	0.6
11	6.5	1.0	6.7	1.4	8.7	1.2	3.8	0.5	4.8	0.9	4.1	0.6
12	8.5	1.8	7.0	1.2	7.4	1.4	3.3	0.4	4.8	0.7	3.9	0.8
13	7.9	1.4	9.7	1.5	6.7	1.3	6.9	1.2	4.6	0.6	4.2	0.7
14	7.2	1.8	6.4	0.9	7.2	1.2	5.4	1.3	5.0	1.0	3.6	0.9
15	6.5	1.3	8.2	1.4	7.5	0.9	7.4	1.6	4.7	0.9	4.0	0.8
16	7.3	1.6	9.9	2.4	6.2	0.7	5.2	1.2	6.4	1.1	3.3	0.6
17	5.6	1.4	5.9	1.3	6.6	1.0	6.9	1.4	5.2	0.7	3.1	0.7
18	5.6	1.1	4.9	1.2	6.7	1.0	5.4	0.9	4.3	0.4	6.1	0.8
19	6.0	0.7	5.8	1.4	6.2	1.2	4.9	0.8	6.0	1.1	5.4	1.3
20	6.7	1.3	7.4	1.5	6.5	0.8	5.4	0.6	5.4	1.1	4.9	1.0
Site Mean, S.D.	6.2	1.04	6.6	1.63	7.0	0.88	5.5	1.06	5.4	1.17	4.8	1.08
Overall Mean SD	5.9	.82										

is probably not a long-term trend. There are numerous shadscale and sagebrush seedlings at all locations where these species occur. There is very little indication of grass reproduction, although in certain areas some seedlings of squirrel tail grass and needle-and-thread grass were seen.

Sheep trails are an obvious part of the landscape throughout the tracts and serve as strong documentation that current use of the area by sheep is excessive. Throughout the tracts the plants are hedged from browsing and grass plants, and grass species are extremely scarce. Where they do exist, they are protected from grazing because they are growing within the shrubs.

Only one location--a northeast-facing slope--was found on the tracts that could be considered good range condition. Grass was common on the site, with beardless wheatgrass the most abundant and needle-and-thread grass, Indian rice grass, squirrel tail grass, and sandberg bluegrass (*Poa sandbergii*) common throughout the openings among the shrubs. Shadscale and sagebrush were the most abundant shrubs, with forsellesia (*Forsellesia*) widely scattered. The latter shrub is a highly preferred plant by both sheep and deer. Winterfat (*Eurotia lanata*) was also widespread on the site.

All grass species and shadscale were reproducing. Sagebrush was also producing seedlings though to a lesser extent. There was no visible evidence of current erosion, and sheep trails were barely visible.

The tracts are ideally suited to grazing by sheep, but it would be more productive if grazing were controlled by keeping plant productivity in balance with animal use. The tracts are not abused beyond recovery. The winter grazing regime has allowed the shrub component of the vegetation to survive, but the late spring grazing has been extremely detrimental to the grasses. If grazing pressure were reduced and grazing stopped earlier, around May 10, there is a good prospect for the range to improve.

Soil Temperature and Soil Moisture

On the tracts, there is a wide range of annual and seasonal variability in soil moisture and temperature. The difference in the precipitation pattern between 1975 and 1976 had a marked effect on plant growth and seed production during 1976. During winter and early spring 1975 an average amount of precipitation was received in regular intervals, which maintained a high soil moisture content. Plants responded favorably, and the density of annual forbs and grasses increased, and perennial vegetation growth and seed production for many species was above normal.

The increased plant production had a positive effect on the rabbit and rodent populations, which increased and survived over the winter.

Because of the lack of precipitation during spring 1976 and the few intense storms of summer, the vegetational growth was not as abundant as in 1975. The annual forb and grass density decreased, and perennial annual growth was poor. Seed production decreased soil moisture, and seed and flower predation by insects increased. Because of their abundance, perennial plants were heavily grazed by rabbits and rodents, which cut branches off near the base of the plant and chewed on the cut portion of the stem. These branches were probably used for a source of moisture, because no other part of the stem was grazed. This grazing increased as the conditions became drier during fall. Species grazed in this manner were Utah juniper, rabbitbrush (*Chrysothamnus nauseosus*), and prickly pear (*Opuntia rhodantha*). On *Opuntia rhodantha*, in addition to the stem girdling, the pods between the spines were eaten.

Soil temperature is extremely important in plant growth. Seed germination and seedling growth are closely regulated by temperature: low temperatures in spring can delay germination and reduce evaporative loss in the soil. Conversely, higher than average soil temperatures can accelerate the growth of plants, especially annual species, and cause a depletion of soil moisture. Early onset of warm temperature and dry surface soils in the spring will dictate to a large extent the presence or absence of annual plants and successful establishment of perennial shrub and forbs.

Salinity and pH

The soil salinity measurements made during the baseline study are valuable as a basis for comparison. These salinity measurements have been useful in the revegetation research now underway in an area adjacent to Tracts U-a and U-b on the north side of the White River. This research has indicated that with the present conditions on the tracts, salt-tolerant native species could be grown on processed oil shale. With the addition of limited amounts of fertilizer and some attention to maintaining adequate water during the period of plant establishment, native shrubs and grasses have been grown in processed oil shale at pH values ranging from 8 to 11 and at EC values ranging from 8 mmhos/cm to 24 mmhos/cm.

Root Growth

Root growth patterns observed during the baseline study are

indicative of the relatively shallow soils of Tracts U-a and U-b. Probably the most shallow rooted shrub is spiny horsebrush. As soil moisture in the top 22 cm (9 in.) of the soil is lost by plant extraction and evaporation, generally in June, spiny horsebrush becomes dormant. Other shrubs and forbs with root systems that are not as shallow may remain active for longer periods. Species like big sagebrush that have both a deep and a shallow root system and a tolerance to drought may remain biologically active over most of the year. The study of root patterns has been useful in providing criteria for propagating certain native plants.

Sagebrush Stem Growth

Measurements of current year's stem growth of sagebrush show that stem growth in this species reflects the growing conditions from year to year. Because of relatively favorable conditions in 1975, stem growth averaged 1.2 cm (0.5 in.) more than in 1976. Whether the measurements of current year's stem growth will be adequate or sensitive enough to show any adverse effects from industrial development remains to be tested.

Threatened or Endangered Species

In the vegetation studies for Tracts U-a and U-b, no species were found that are on the list of "Proposed Endangered Status from Some 1700 US Vascular Plant Taxa" (CFR 41, June 16, 1976). This should not be construed to mean that endangered plants do not exist there. *Eriogonum ephedroides*, *Gilia mevickeae*, and *Astragalus lutosus* have been identified by the BLM as species of concern in connection with the tracts. A specimen of *Eriogonum ephedroides* was collected 10 mi south of Bonanza and is on deposit in the Intermountain Herbarium.

5. EVALUATION OF BASELINE PROGRAM

Several issues must be considered in evaluating the vegetation baseline study: a) the usefulness of the information, b) the rationale for a baseline study and the adequacy of the guidelines to respond to that rationale, and c) the problem of achieving statistical adequacy in sampling, given the problem of variability of vegetation on Tracts U-a and U-b.

The information generated concerning the vegetation has immediate use and application in revegetation research currently underway

on the tracts and at Utah State University. The species composition of the vegetation, amount of plant cover, size of plants, percentage of bare ground, rooting habits, and natural salinity tolerance are but a few of the parameters studied that provide criteria for planning and background knowledge for revegetation studies. In many respects it has been especially effective for the group involved in the vegetation studies to also be doing the revegetation research. Other components of the baseline study team have also drawn upon the vegetation information in carrying out their work. How much use will be made of the baseline vegetation information by future planners other than those in revegetation is difficult to predict.

There is little doubt that the described set of conditions, including the measured variability, can be used to determine impacts of development in the future. This is discussed in more detail below.

The rationale for the baseline study is basically sound, i.e. studying pre-existing conditions and describing them to provide a standard of comparison for any future departures from the norm. However, a two-year period for sampling biological phenomena is not adequate for establishing a solid information base because of the high year-to-year variability. It should be clear that the information base in the biological area is much more variable than in the geological or physical area. Another unusual growing season could add a much different set of data. Instead, the biological data should be considered as an introduction to longer-term study and a documentation of the existing level of natural variability.

Adequacy of sampling in terms of statistical reliability was a requirement of the baseline study. However, this requirement was realistic only in terms of the dominant (and frequently occurring) plant species. For example, in the sagebrush-greasewood vegetation type, 136 big sagebrush plants were measured for height in the fall 1975 sampling period; because this is a relatively uniform characteristic, the mean height of 29.2 cm (11.5 in.) varied only from 27.3 cm to 31.1 cm (10.8 in. to 12.2 in.) in 90% of the cases. To adequately sample sagebrush height within 25% of the mean of a 90% statistical reliability, 12 samples were required. Thus, the 136 observations made were an adequate sample. Sagebrush cover was also adequately sampled. The 64 plots sampled had sagebrush in them. The mean cover of sagebrush was 2395 cm² with a 90% confidence interval ranging from 1941 cm² to 2840 cm². Under these conditions, 53 samples were required to estimate within 25% of the mean with a statistical reliability of 90%. In contrast, density could not be adequately sampled. Sixty-four plots out of 100 contained sagebrush with an average density of 5.1 individuals and a confidence interval ranging from 3.8 to 6.5 individuals. Because of a greater variability in density,

possibly from a plant aggregation effect, 99 plots were required for statistical adequacy at the 90% confidence level 25% above the mean in a fall period.

It is impossible to achieve sampling adequacy when only one or two plants of a species are counted, because such a small sample does not provide enough information for statistical calculations. Species of high variability, such as winterfat (*Eurotia lanata*), recently changed to (*Ceratoides lanata*), are an example. Within the 100 plots sampled in fall 1975 in the sagebrush-greasewood vegetation type, 8 height measurements of winterfat were recorded but 9 were required for statistical adequacy. On 6 plots, cover estimates were made, but the cover was so variable among plots that 37.5 plots were required for statistical adequacy. The density of winterfat was counted on 6 plots, but 25 were required to adequately describe the occurrence of the plant.

The monitoring program has indicated that it is practical to sample only the dominant and regularly occurring species, because to sample any others would require excessive sampling in order to achieve statistical reliability. Future programs, therefore, should be based on sampling height, cover, and density as outlined in the Detailed Development Plan, but only on selected dominant species. With such a method, leader growth of big sagebrush would be measured as an indication of potential impacts on the entire floral portion of the biota. Further, measurement of productivity of annual plant species would also provide a data record that began with the baseline program and would indicate variations from this data curve.

B. TERRESTRIAL VERTEBRATES

Terrestrial vertebrates--mammal, birds, reptiles, and amphibians--were studied to establish a list of the species present and their spatial and temporal distribution, density and abundance, and relationship to the abiotic and biotic factors on the tracts.

1. GENERAL SAMPLING (MAMMALS, BIRDS, REPTILES, AND AMPHIBIANS)

a. Methodology

Sampling for terrestrial vertebrates was conducted six times a year for two years. Sampling periods were three weeks on a bimonthly basis beginning in December 1974 and ending in October 1976. Winter vertebrate activity was sampled in February, spring activity in April and June, summer activity in August, and fall activity in October and December. Two wildlife biologists were on the tracts during each sampling period.

The species list and spatial distribution were established by flushing transects in the different vegetation types, live-trapping for small nocturnal mammals in the different vegetation types, mist-netting for bats, general observations while driving and hiking throughout the tracts, and literature review. Temporal distribution of the vertebrates was established through the bimonthly sampling.

Species abundance was determined from flushing transects. Three permanent transects were set up in the four vegetation types. (The transect and trap-grid locations are shown on Figure IV-2.) A 1-km and two 0.5-km transects were placed in the sagebrush-greasewood type, found primarily on the floor of Southam Canyon and Asphalt Wash. The same transects were placed in the juniper type in the uplands and in the shadscale type on the rolling hills in the eastern portion of the tracts. Three 0.5-km transects were placed in the riparian type, two on the White River bottomlands and one on Evacuation Creek. Five of the 12 transects were in the 1.6-km boundary area around the tracts and seven were on the tracts.

The transects were walked for birds in the morning between sunrise and three and a half hours after sunrise. The same transects were walked in the evening between two hours prior to sunset and one hour after sunset for mammals. In June and August, the same transects were walked for reptiles between three and a half hours after sunrise and six hours after sunrise. Each transect was walked for five consecutive days, barring high winds, heavy rain, and snow. Within the length of a transect,

any reptile, bird, or mammal visually observed was identified to species, where possible, or to genus, family, or order, and its perpendicular distance (in meters) from the transect line was recorded. Species identification was also made using auditory stimuli. Transects generated three aspects of abundance: the number of a species, genus, family, etc., in a vegetation type; the mean distance from the transect line where the species, etc., were observed; and the frequency of observation. (Perpendicular distances were usually estimated and occasionally verified by measuring the actual distance.) Densities were not calculated from transect data due to contradictory assumptions in the published formulae (Anderson et al. 1976; Emlen 1971; and Gross et al. 1974).

Species density was generated by live-trap grids, one in each vegetation type (Figure IV-2). The areas were trapped once a year, in August, for five consecutive nights. The grids were also scheduled for April, but trapping was discontinued because of cold and wet conditions that resulted in trap mortality exceeding 10% of the individuals captured. Three of the grids in sagebrush-greasewood, juniper, and shadscale covered 2.72 hectares (ha). One hundred and forty-four Sherman live traps (7.6 x 7.6 x 25.4 cm) were set in a 12 x 12 grid, 15 m between each trap. The riparian trap grid covered 1.36 ha in a 6 x 12 design, 15 m between each trap. Each trap was baited with rolled oats prior to sunset. Traps were checked the next morning, emptied, and left closed until sunset.

A captured mammal was identified to species, where possible, and aged (adult or juvenile), sexed, marked individually by toe-clipping, and released. All capture and recapture locations were recorded, as were physical condition (pregnant, torpor, etc.) and unusual activity (double and triple captures in one trap, etc.).

Densities were calculated according to $D = n/a$, where:

D = density

n = number of individuals captured

a = area of trap grid (2.72 or 1.36 ha)

Transect trapping for small nocturnal mammals was scheduled for each sampling period. Due to high mortality resulting from cold weather, transect trapping was not conducted during part of December 1974, February, part of April, part of October, December 1975, and February 1976. Twenty-four Sherman live traps straddled each flushing transect. Traps were set 15 m apart, with two rows, 165 m long. The same procedure used in the grids was used on the transect traps, with one exception. Hair was clipped from just above the tail in order to identify recaptures. Transect trapping aided in the species list, species distribution, both spatial and temporal. Abundance of a species was calculated according to individuals captured/100 trap nights (24 traps x 5 night = 120 trap nights).

Mist-netting for bats was conducted for five nights in May and August 1976. Nets were set up one-half hour prior to sunset and left up until 1:00 a.m. to 3:00 a.m. Nets were checked every 15 minutes. Any capture was identified to species, where possible, or to genus, etc., and released. Nets were placed in and along the White River near Highway 40, over a gas pond in Asphalt Wash, and at a stock-watering pond north of Bonanza, Utah.

Literature used in species identification, presence or absence, and distribution were Stebbins (1966) for amphibians and reptiles; Bailey and Neidrach (1965), Behle and Perry (1975), Robbins et al. (1965), and Peterson (1961) for birds; and Armstrong (1972), Barbour and Davis (1969), Burt and Grossenheider (1964), Durrant (1952), and Murie (1975) for mammals. Recent vertebrate studies in and near the tracts were done by Behle and Perry (1975), Perry (1975), Olsen (1973), and Ranck (1961). For comparison of yearly abundance, seasonal abundance and abundance in the four vegetation types, the data were analyzed using one-way analysis of variance, ranking the means where necessary according to the Least Significant Difference (LSD) (Ostle 1963).

During the baseline study, various aspects of the methodology were changed, primarily due to field conditions. Transects were to be walked for birds two and a half hours after sunrise. This was extended by one hour during the winter, spring, and fall because the birds were not active after sunrise on cold mornings. Mammal transects were extended to one hour past sunset. This provided a good opportunity to observe the early evening bats, as well as additional mammals flushed by use of a headlamp.

The usual method of mathematical analysis of vertebrate density in home range were found to be inadequate for this particular project. The Schnabel Estimator (1938) as modified by Overton (1965) was not used because of the large number of required assumptions that have to be made. This situation applies to all the known estimators as pointed out by Anderson (1975). Home ranges were not calculated by the Jennrich and Turner method (1969), since only 30% of the rodents captured displayed a capture pattern that could be used in the equation. For example, a number of rodents were captured five nights in a row in the same trap, and therefore their home range could not be computed. No home ranges are given since no adequate methodology exists. Densities were to be calculated from flushing transect data. This was not done because the formula does not include all observations. It is sound scientific principle that data should not be eliminated just because it does not fit into a certain category, and yet that is what would have had to be done in order to apply the above data reduction techniques. Rodent densities from grid data are the number of animals trapped divided by the grid area.

b. Summary of Results

Most terrestrial vertebrates studied on the tracts can be placed in two general orders: 1) seasonal users--avian and mammalian spring-summer residents, fall-winter residents, and transients and 2) permanent users--amphibian, reptilian, avian, and mammalian permanent residents. A third group of birds and mammals observed in this study and cited in the literature could not be placed in either order and are called unclassified users.

Seasonal Users

Most of the birds on the tracts and about two-fifths of the mammals are seasonal users (108 species of birds of a total 131 species, or 82%, and 15 species of mammals of a total 38, or 39%). Eight bird species were classified as fall-winter residents, 38 species as transients, and 61 species as spring-summer residents. Mammalian spring-summer residents and transients include 12 species of bats and domestic cattle. The only fall-winter mammalian residents are the domestic sheep.

The eight fall-winter avian residents are listed according to order and species, habitat distribution, and earliest/latest sightings on Table IV-29. Their habitat use is calculated as a percentage of presence in a specific habitat divided by presence on the tracts. For example, goshawks had been observed during three sampling periods, and thus the denominator equalled 3. It had been observed at least once in sagebrush-greasewood ($1 \div 3 \times 100 = 33\%$ occurrence), once in juniper and shadscale (33% for each), and three times in riparian (100% occurrence). These calculations coincide with the biologists' observations throughout the tracts. Where there is any question or data are lacking, X signifies presence and an 0 absence.

Among the winter residents, observations of bald eagles and goshawks have been made. Eagles have usually been seen along the White River. The number of both species is low, although four goshawks were seen in October 1976. These two raptors and five passerine species were present during winter 1975 and 1976. The rough-legged hawk, a consistent resident north of the tracts, used the tracts in 1976 probably because of the high rodent densities.

The abundance of winter residents increased markedly from 1975 to 1976. Few seasonal birds -- a total of 195 -- were seen on transects in late fall and winter 1975 because the weather was cold and the ground covered with snow. Spring 1975 was wet,

TABLE IV-29

AVIAN WINTER RESIDENTS' SPATIAL AND TEMPORAL DISTRIBUTION

ONE YEAR* and TWO YEAR AVIAN FALL-WINTER RESIDENTS Order-Species	I. HABITAT DISTRIBUTION				II. TEMPORAL DISTRIBUTION	
	Occurrence per Total Sightings, %				Earliest Sighting, Month, Year	Latest Sighting, Month
	Greasewood	Juniper	Shadscale	Riparian		
Falconiformes						
Goshawk	33	33	33	100	October	February
Rough-legged Hawk*	X	X	X	0	February, 76	
Bald Eagle	0	33	66	100	December	February
Passeriformes						
Bushtit	33	66	0	50	October	June
Gray-crowned Rosy Finch	100	66	66	66	December	February
Black Rosy Finch	40	40	60	80	December	April
Dark-eyed Junco	56	78	22	89	October	June
Tree Sparrow	33	0	0	66	October	February

X - presence - insufficient data or questionable observation

0 - absence

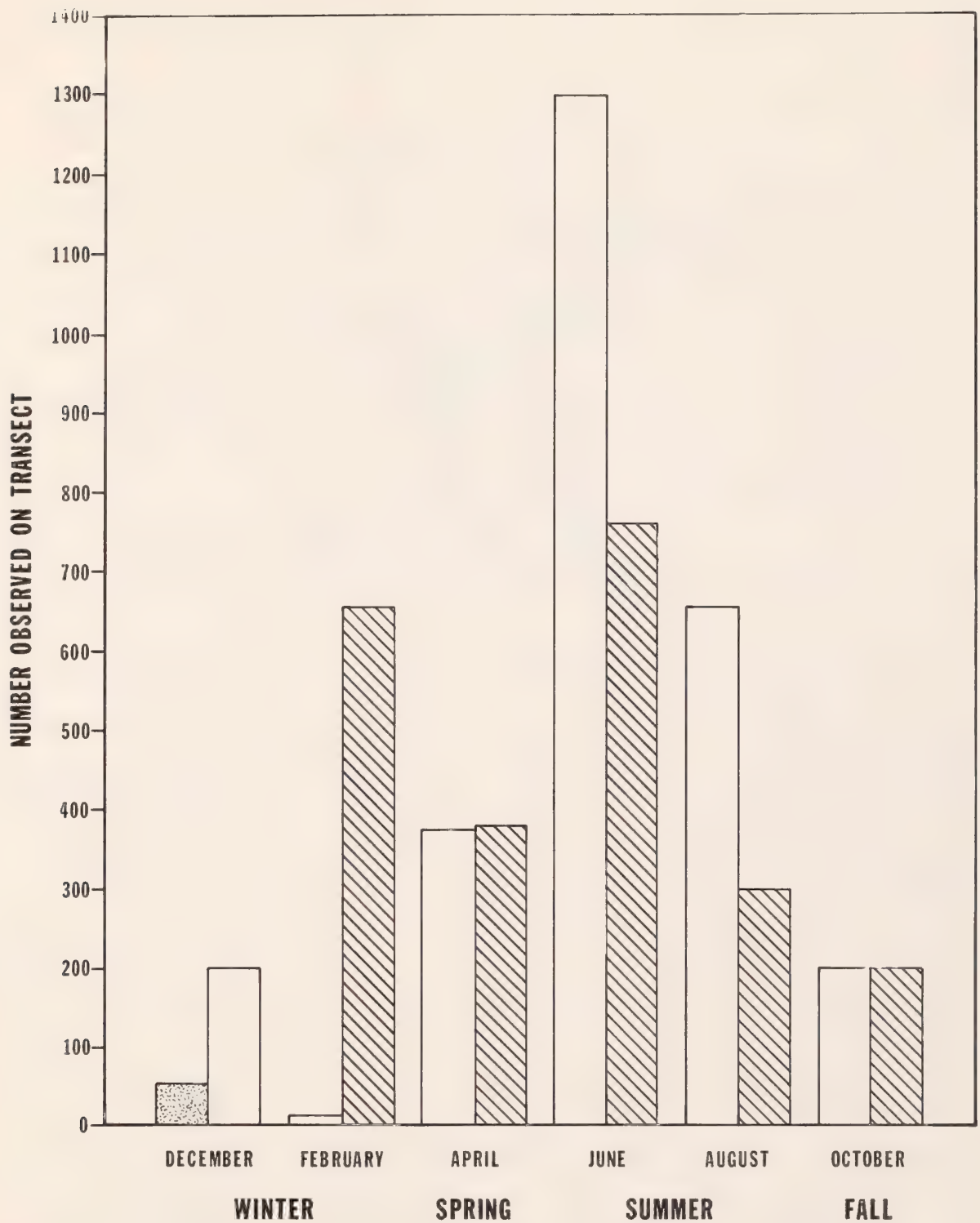
leading to high productivity in seeds and forage through the summer and fall. During late fall and winter 1976, 922 birds were seen on transects, primarily passerine seed eaters (Figure IV-14 - December 1975 and February 1976 sightings). The weather was mild, and snow cover was less than in 1975. The most abundant winter residents were the rosy finches, predominantly black and dark-eyed juncos (previously known as Oregon juncos).

Thirty-eight avian transients used the tracts during the two-year study. Transients are lumped as migrants and wanderers, the latter referring to species like the short-eared owl, Clark's nutcracker, mountain chickadee, the two nuthatches, and cedar waxwings. One of the transients was the endangered whooping crane. A single whooper flew over the tracts in October 1976 with about 300 sandhill cranes, apparently from the Gray's Lake, Idaho, flock. Transient distribution, though patchy at best, was predominantly keyed to the riparian vegetation along the White River (Table IV-30).

Eighteen of the transient species were present during both years of the study. Two, the white-crowned sparrow and the song sparrow, may be summer residents. Transient abundance in both the spring and fall of 1975 and 1976 was consistently stable (Figure IV-14 - April and October sightings). Although no sandhill cranes were seen on transects, 2000 to 5000 fly directly over the tracts every April and October. (There are probably very few on the tracts.)

There were 61 species of avian spring-summer residents. Fifty-five of these species were present during 1975 and 1976. Five of the six species present only one year (1975) were insectivorous birds, gnatcatchers, vireos and warblers. The one resident present in 1976 was the mockingbird, seen only in Asphalt Wash. Black-tailed gnatcatchers, a "hypothetical species" for the state of Utah (Behle and Perry 1975), were observed along the White River, Evacuation Creek, and in Southam Canyon. Although no collections were made, the species was positively identified. Distribution according to habitats (Table IV-31) were indicative of specific preferences for some species and general preferences for others. Herons, ducks, geese, shore birds, swallows, gnatcatchers, vireos, and warblers were for the most part, found along Evacuation Creek and the White River. Sage thrashers, meadowlarks, black-throated sparrows, and sage sparrows were predominant in the sagebrush-greasewood and shadscale. Gray flycatchers and chipping sparrows were particular to juniper. Raptors, doves, nighthawks, Say's phoebes, rock wrens, bluebirds, house finches, and Brewer's sparrows were found throughout the tracts.

Abundance of spring-summer residents peaked in June and consistently decreased by August in both years. The spring of 1975 (April, June, and August), a wet period with abundant



LEGEND

1974 SIGHTING

 1975 SIGHTING

 1976 SIGHTING

SEASONAL AVIAN ABUNDANCE

BY MONTHS FROM TRANSECTS FOR SUMMER AND WINTER RESIDENTS



TABLE IV-30

AVIAN TRANSIENTS' SPATIAL AND TEMPORAL DISTRIBUTION

ONE YEAR* and TWO YEAR AVIAN TRANSIENTS Order/Species	I. HABITAT DISTRIBUTION				Month and Year Observed
	Occurrence per Total Sightings, %				
	Sagebrush- Greasewood	Juniper	Shadscale	Riparian	
Anseriformes					
Pintail*	0	0	0	X	June, 75
American Wigeon*	0	0	0	X	June, 75
Northern Shoveler	0	0	0	X	April, 76, June, 75, 76
Blue-winged Teal*	0	0	0	X	October, 76
Cinnamon Teal*	0	0	0	X	April, 76
Green-winged Teal	0	0	0	X	April, 75, 76, June, 76
Common Merganser	0	0	0	X	Feb., 76, April, 75
Falconiformes					
Swainson's Hawk*	0	0	X	0	August, 76
Galliformes					
Ring-necked Pheasant*	X	0	0	X	June, 76
Gruiformes					
Sandhill Crane	Flying over tracts				April, 75, 76, Oct., 75, 76
Whooping Crane*	Flying over tracts				October, 76
Charadriiformes					
Greater Yellowlegs*	0	0	0	X	April, 76

TABLE IV-30 (CON'T.)

ONE YEAR* and TWO YEAR AVIAN TRANSIENTS Order/Species	I. HABITAT DISTRIBUTION				Month and Year Observed
	Occurrence per Total Sightings, %				
	Sagebrush- Greasewood	Juniper	Shadscale	Riparian	
Charadriiformes (Continued)					
Common Snipe*	0	0	0	X	April, 75
Strigiformes					
Short-eared Owl*	0	0	0	X	April, 75
Coraciiformes					
Belted Kingfisher	0	0	0	X	April, 76 & Oct., 75
Piciformes					
Yellow-bellied Sapsucker	0	0	0	X	Apr., 75, June, 75 & Oct., 76
Passeriformes					
Barn Swallow	0	0	X	X	October, 75, 76
Clark's Nutcracker*	0	X	0	0	October 75
Mountain Chickadee*	0	X	0	X	October 76
White-breasted Nuthatch*	0	0	0	X	August 76
Red-breasted Nuthatch*	0	X	0	0	August 76
Brown Creeper*	0	0	0	X	October 76
House Wren*	X	0	0	X	April 76 & Aug. 76
Bewick's Wren	X	X	0	X	April 76
Hermit Thrush*	0	0	0	X	June 76 & Oct. 76
Swainson's Thrush	0	0	0	X	Aug. 76 & Oct. 75

TABLE IV-30 (CON'T.)

ONE YEAR* and TWO YEAR AVIAN TRANSIENTS Order/Species	I. HABITAT DISTRIBUTION				Month and Year Observed
	Occurrence per Total Sightings, %				
	Sagebrush- Greasewood	Juniper	Shadscale	Riparian	
Passeriformes (Continued)					
Western Bluebird*	0	X	0	X	April, 75
Townsend's Solitaire	0	X	0	X	April 75, 76 & Oct. 75
Ruby-crowned Kinglet	0	X	0	X	October 75, 76
Water Pipit	0	0	X	X	April 75, 76 & Oct. 76
Cedar Waxwing	0	0	0	X	June 75, 76
Pine Siskin	0	X	0	X	Oct. 75 & Dec. 76
Green-tailed Towhee	X	0	0	X	April 75 & August 76
Savannah Sparrow*	0	0	X	X	April 76
Vesper Sparrow	0	0	X	0	April 75, 76
Gray-headed Junco*	0	X	0	0	June 76
White-crowned Sparrow <u>1/</u>	50	17	17	99	Apr. 75, 76, June 75, 76, & Oct. 75, 76
Song Sparrow	0	0	0	99	Apr. 75, June 75, 76, & Oct. 75

X - presence - insufficient data or questionable observation

0 - absence

^{1/}May be summer resident

TABLE IV-31

AVIAN SUMMER RESIDENTS' SPATIAL AND TEMPORAL DISTRIBUTION

ONE YEAR* and TWO YEAR AVIAN SUMMER RESIDENTS Order/Species	I. HABITAT DISTRIBUTION				II. TEMPORAL DISTRIBUTION	
	Occurrence per Total Sightings, %				Earliest Sighting, Month	Latest Sighting, Month
	Sagebrush- Greasewood	Juniper	Shadscale	Riparian		
Ciconiiformes						
Great Blue Heron	0	0	0	100	April	October
Anseriformes						
Mallard	0	0	0	100	April	December
Gadwall	0	0	0	100	April	June
Canada Goose	0	0	0	100	February	June
Falconiformes						
Turkey Vulture	33	17	67	100	April	August
Red-tailed Hawk	88	75	100	88	April	October
Prairie Falcon	62	50	75	62	February	October
American Kestrel	89	67	89	56	April	December
Charadriiformes						
Spotted Sandpiper	0	0	0	100	June	August
Killdeer	0	0	0	100	April	August
Columbiformes						
Mourning Dove	100	62	75	100	April	October

TABLE IV-31 (CON'T.)

ONE YEAR* and TWO YEAR AVIAN SUMMER RESIDENTS Order/Species	I. HABITAT DISTRIBUTION				II. TEMPORAL DISTRIBUTION	
	Occurrence per Total Sightings, %				Earliest Sighting, Month	Latest Sighting, Month
	Sagebrush- Greasewood	Juniper	Shadscale	Riparian		
Caprimulgiformes						
Common Nighthawk	100	100	100	100	June	August
Apodiformes						
White-throated Swift	60	20	20	100	April	August
Broad-tailed Hummingbird	X	X	X	X	April	June
Passeriformes						
Eastern Kingbird	0	0	0	X	June	August
Western Kingbird	60	20	40	40	April	August
Ash-throated Flycatcher	50	0	25	100	June	August
Say's Phoebe	100	83	83	100	April	August
Western Wood Peewee	0	0	0	X	June	August
Willow (Traill's) Flycatcher	0	0	0	X	June	
Gray Flycatcher	60	100	0	20	April	August
Cliff Swallow	50	0	75	100	June	August
Violet-green Swallow	50	17	33	83	April	August
Rough-winged Swallow	40	0	40	100	April	August
Rock Wren	100	88	100	88	April	October
Mockingbird*	X				June, 76	

TABLE IV-31 (CON'T.)

ONE YEAR* and TWO YEAR AVIAN SUMMER RESIDENTS Order/Species	I. HABITAT DISTRIBUTION				II. TEMPORAL DISTRIBUTION	
	Occurrence Per Total Sightings, %				Earliest Sighting, Month	Latest Sighting, Month
	Sagebrush- Greasewood	Juniper	Shadscale	Riparian		
Passeriformes (Continued)						
Sage Thrasher	86	14	100	0	April	October
American Robin	44	33	22	89	February	October
Mountain Bluebird	100	78	56	67	April	December
Blue-gray Gnatcatcher	28	28	0	100	April	October
Black-tailed Gnatcatcher	X	X	0	X	April, 75	August, 75
Starling	0	0	67	83	April	October
Solitary Vireo	0	0	0	X	June, 75	
Warbling Vireo	0	0	0	100	June	August
Orange-crowned Warbler*	0	0	0	X	April, 75	June, 75
Virginia's Warbler*	X	0	0	X	June, 75	
Yellow Warbler	25	0	25	100	June	August
Yellow-rumped Warbler (Audobon's and Myrtle)	40	40	0	100	April	October
Black-throated Gray Warbler	40	60	0	80	April	August
MacGillivray's Warbler	X	0	0	X	June	
Common Yellowthroat	0	0	0	X	June	
Yellow-breasted Chat	0	0	0	100	June	August
Wilson's Warbler* ^{1/}	25	0	0	100	June, 75	October, 76

^{1/}Fall transient in Oct., 1976.

TABLE IV-31 (CON'T.)

ONE YEAR* and TWO YEAR AVIAN SUMMER RESIDENTS Order/Species	I. HABITAT DISTRIBUTION				II. TEMPORAL DISTRIBUTION	
	Occurence per Total Sightings, %				Earliest Sighting, Month	Latest Sighting, Month
	Sagebrush- Greasewood	Juniper	Shadscale	Riparian		
Passeriformes (Continued)						
Western Meadowlark	88	25	100	75	April	October
Red-winged Blackbird	50	25	0	100	April	October
Scott's Oriole	X	X	0	X	June	August
Northern Oriole (Bullock's)	0	0	0	X	June	August
Brewer's Blackbird	28	14	57	86	February	October
Brown-headed Cowbird	X	X	X	X	June	August
Western Tanager	25	50	0	100	June	August
Black-headed Grosbeak	0	0	0	X	June	August
Blue Grosbeak	0	0	0	X	June	August
Lazuli Bunting	X	X	0	X	June	August
House Finch	57	86	57	71	April	October
American Goldfinch	0	0	0	X	June	
Rufous-sided Towhee	88	25	12	100	April	December
Lark Sparrow	86	43	71	57	April	October
Black-throated Sparrow	100	50	100	50	April	August
Sage Sparrow	67	33	100	33	February	October
Chipping Sparrow	50	75	12	50	April	December
Brewer's Sparrow	67	33	67	83	April	August

X - presence - insufficient data or questionable observation

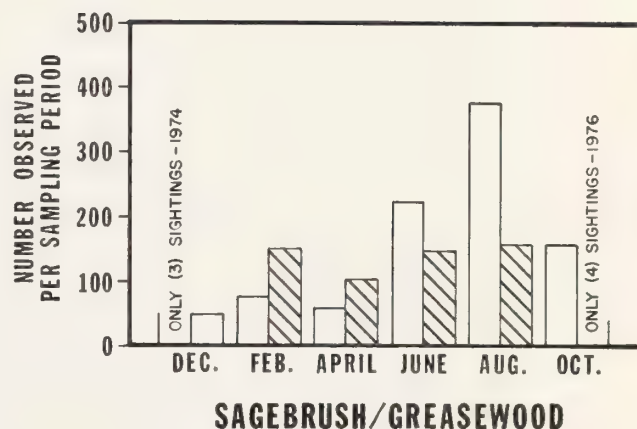
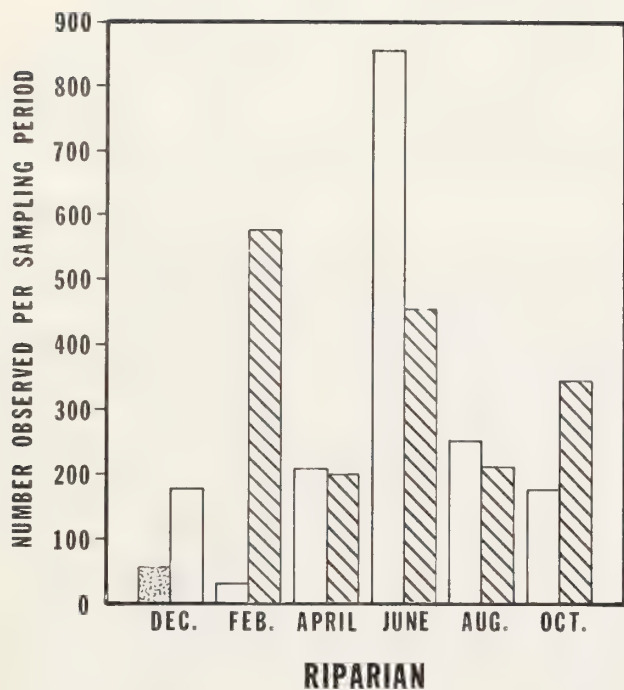
0 - absence

plant growth and numerous insects, had the highest concentration of birds -- 2250 were seen on the tracts. Insectivorous birds, for example cliff swallows and the five one-year residents, were a major portion of the birds observed. The spring of 1976 was dry and warm. Resident abundance in June decreased to 1458, a 35% decrease (Figure IV-14 - April, June, and August sightings).

Comparing abundance among vegetation types, the riparian type ranked as the most important for the seasonal birds ($n = 144$, treatment $df = 3$, error $df = 140$, total $df = 143$, Table F value for 150 df error at $p = 0.95$ or at the 95% level of confidence = 2.67, computed $F = 7.91^*$). Without this area, both avian species diversity and avian abundance would be drastically reduced (Figure IV-15). Of note was an increased abundance in sagebrush-greasewood in August, whereas abundance in other three habitats decreased. Perhaps cover or food availability were the important factors. Why a general decrease in abundance occurred from June to August is unknown. Certain aspects of this phenomenon will be discussed later. Seasonal abundance (Figure IV-14) showed drastic changes, with June the month of highest concentration. Overall abundance (Figure IV-15) on a year-to-year comparison remained the same ($n = 48$, treatment $df = 1$, error $df = 46$, total $df = 47$, Table F value at 44 df error = 4.06, $p = 0.95$, computed $F = 0.01$).

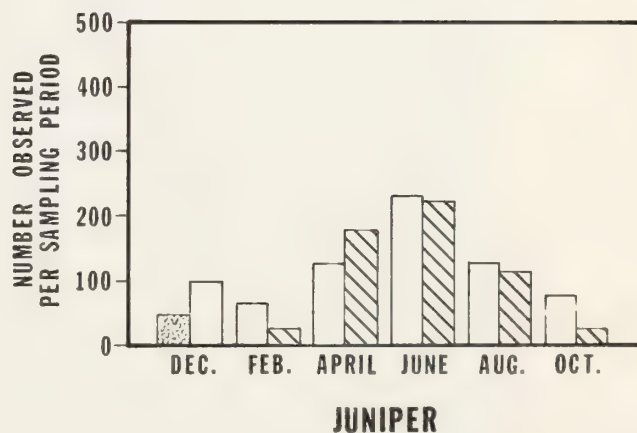
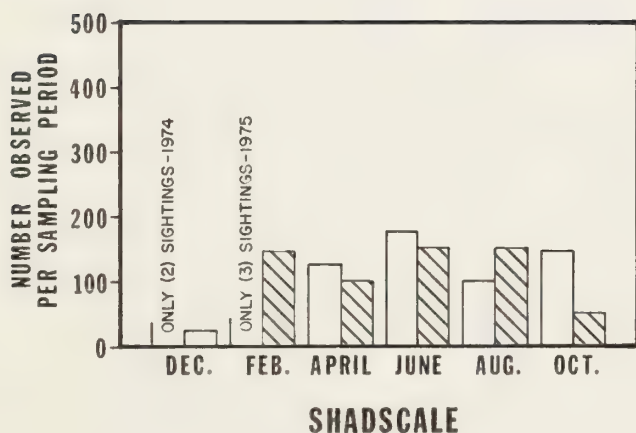
Mammalian summer residents, winter residents, and transients are listed on Table IV-32. Residency and transient status for bats is unconfirmed and based on two mist-net samplings in May and August 1976. The little brown myotis, long-eared myotis, big brown bat, and pallid bat were netted at both times and are thus considered residents. The silver-haired and big-eared bats were netted in May only, and the long-legged myotis, western pipistrelle, and hoary bat in August only. The Yuma, California, and small-footed myotis identifications remained questionable. Experts have trouble keying some myotis to species. Because of the unequal netting in May and August, residence status is questionable. Distribution is also questionable. The only place where bats were consistently netted was a small pond formed by a gas well in Asphalt Wash (south of Tract U-a). Trying to net bats on the White River was never successful. The distribution of unidentified bats from transects showed that the sagebrush-greasewood and juniper are usual habitats for feeding. The river area is used in August when the evenings are warm. In June, the bats and insects are active in the uplands due to the cold-sink qualities of the river canyon. The number of bats observed on transects increased from 22 in 1975 to 45 in 1976.

*In general, f values less than 1 indicate that there are no significant differences in the data while f values increasing from 1 indicate a higher probability that the data are significantly different.



LEGEND

-  1974 SIGHTING
-  1975 SIGHTING
-  1976 SIGHTING



AVIAN ABUNDANCE

SEASONAL AND PERMANENT RESIDENTS IN FOUR VEGETATION TYPES

FIGURE IV-15

TABLE IV-32

SEASONAL MAMMALIAN DISTRIBUTION AND ABUNDANCE

MAMMALIAN SUMMER RESIDENTS, WINTER RESIDENTS AND TRANSIENTS Order/Species	I. HABITAT DISTRIBUTION				Month and Year (1976) Observed
	Occurrence per				
	Total Sightings, %				
	Sagebrush- Greasewood	Juniper	Shadscale	Riparian	
SUMMER RESIDENTS					
Chiroptera					
Little Brown Myotis	X	0	X	0	May, August
Long-eared Myotis	X	0	0	0	May
Big Brown Bat	X	0	0	0	May
Pallid Bat	X	0	0	0	May
Bats, unidentified species	100	80	60	60	May, June, August, 75 & 76
Artiodactyla					
Domestic Cattle	0	0	57	100	June, Aug, Oct., 75 & 76
Domestic Horse	0	0	0	X	August, 76
WINTER RESIDENT					
Artiodactyla					
Domestic Sheep	55	55	77	66	Dec., Feb., Apr., 75 & 76
TRANSIENTS					
Chiroptera					
Yuma Myotis	0	0	0	0	May, August, 76
Long-legged Myotis	X	0	0	0	August

TABLE IV-32 (CON'T.)

MAMMALIAN SUMMER RESIDENTS, WINTER RESIDENTS AND TRANSIENTS Order/Species	I. HABITAT DISTRIBUTION				Month and Year (1976) Observed
	Occurrence per Total Sightings, %				
	Sagebrush- Greasewood	Juniper	Shadscale	Riparian	
TRANSIENTS (CONTINUED)					
Chiroptera (continued)					
California Myotis	0	0	0	0	August
Small-footed Myotis	0	0	0	0	May
Silver-haired Bat	X	0	0	0	May
Western Pipistrelle	X	0	0	0	August
Hoary Bat	X	0	0	0	August
Western Big-eared Bat	X	0	0	0	May

Two other summer residents are domestic cattle and horses. The cattle, Herefords, range throughout the riparian area, moving up the sagebrush-greasewood draws as the summer progresses. Domestic horses were seen only once near Hells Hole Canyon during a White River float in August 1976.

Sheep are the mammalian winter residents. Approximately 2000 spend from December to April in and around Southam Canyon. The eastern portion of the tracts is the center of the stock driveway through which 10,000+ sheep pass each fall and spring. Some sheep are held in this area during the spring awaiting shearing.

Permanent Users

The permanent residents on the tracts belong to four vertebrate classes -- Amphibia, Reptilia, Aves, and Mammalia. The four amphibians on the tracts are found only along the White River. They are the Great Basin spadefoot toad, Woodhouse's toad, the leopard frog, and the chorus frog. Their activity period coincides with spring weather conditions. In 1975 they were not active until June because of the cold weather during May. In 1976 activity began sometime in May. In August of both years the Woodhouse's toad and leopard frog were the only amphibians seen. Amphibian abundance was highest in June. Because of their restricted habitat and nocturnal habits, no counts were made. According to qualitative observation, the toads and leopard frog are uncommon and the chorus frog rare. No amphibians live in Evacuation Creek, and their absence is understandable because the creek varies from dry to flash-flood and the water would be toxic.

During the baseline assessment, six lizard species and five snake species were identified on the tracts. They were distributed throughout the tracts, some in specific habitats, some general (refer to Section IV. B. 2.c for a supplementary survey of amphibians and reptiles). They were active from April through October, sporadically in April and October, and at their peak in June and August. The lizards were by far the most abundant vertebrates on the tracts. Species composition, distribution, and abundance remained stable through the two-year assessment.

Species, habitat distribution, and temporal distribution are listed on Table IV-33. Eastern fence and tree lizards were associated with vertical surfaces such as trees, rock outcrops, and rock walls. Sagebrush lizards were found in and among sagebrush in each type. Side-blotched lizards occupied open, unvegetated areas in each plant type. Short-horned lizards

TABLE IV-33

REPTILE DISTRIBUTION AND ABUNDANCE

REPTILES Order/Species	I. HABITAT DISTRIBUTION				II. ABUNDANCE	
	Occurrence per Total Sightings, %				Number Observed on Transects	
	Sagebrush- Greasewood	Juniper	Shadscale	Riparian	1975	1976
Squamata						
Eastern Fence Lizard	28	71	57	100	27	19
Sagebrush Lizard	75	62	75	88	181	194
Side-blotched Lizard	75	88	50	62	27	47
Tree Lizard	14	71	0	86	1	9
Short-horned Lizard	20	0	100	0	9	2
Western Whiptail	67	83	50	83	37	50
Racer	0	0	0	100	4	1
Striped Whipsnake	60	40	60	60	3	1
Gopher Snake	86	57	57	71	2	0
Western Terrestrial Garter Snake	0	0	0	100	2	0

(horned toad) were particular to shadscale, and Shiptails were particular to sagebrush-greasewood.

The racer and garter snakes were restricted to the White River bottomland. The shipsnake was usually found around rock outcrops in each type. The rattlesnake (appropriately called the midget-faded rattler) seemed to prefer greasewood in or near the dry washes. No rattlers occurred on the White River, but were found along Evacuation Creek. Gopher snakes were common in and under juniper trees, in the sagebrush-greasewood, and in the dense grass by the river.

Abundance data indicate there are a lot of lizards and not very many snakes. Although the number observed does not approach the number of birds and mammals seen, most of the lizards seen were flushed within 1 m of the transect line and were not visible beyond 5 m from the transect line. The greatest concentration of lizards was found in the juniper type ($n = 16$, treatment $df = 3$, error $df = 12$, total $df = 15$, Table F value = 3.29 at $p = 0.95$, computed $F = 17.8$). The other three vegetation types were similar in terms of abundance (Figure IV-16). Snake abundance appeared to decrease from 1975 to 1976.

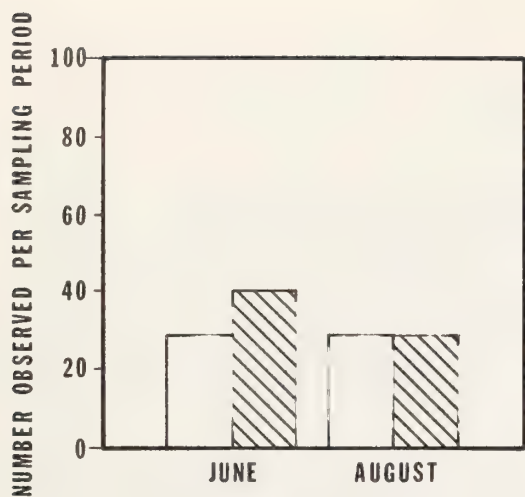
Reptiles are the most stable class of vertebrates on the tracts, each having a relatively well-defined distribution and activity period. Also, the lizards are the most abundant vertebrates and are stable in terms of population flux.

There were 13 species of permanent avian residents--4 raptors, 2 woodpeckers, and 7 passerines. Their distribution and abundance are listed on Table IV-34. All but common ravens nest on the tracts, and ravens use the tracts to feed and forage. None of the permanent residents are rare or endangered.

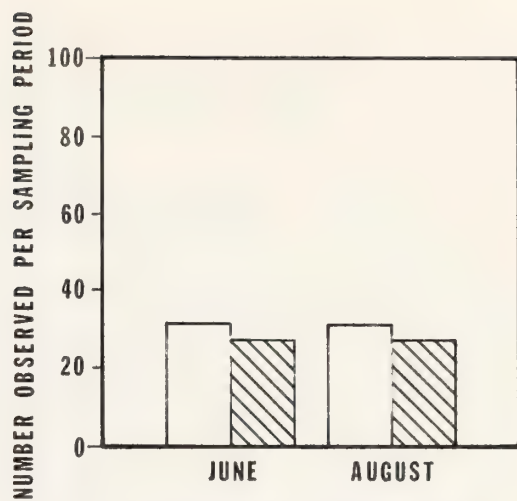
The number of permanent avians increased in 1976 from 829 to 1129 (Figure IV-17). All habitats had a relatively equal use throughout both years. The overall use patterns of seasonal and permanent avians according to plant types is shown on Figure IV-15.

The spatial distribution of these birds may provide year-round indicators of change tract-wide and in specific plant types. The marsh hawk, who preys mainly on small mammals, is particular to the shadscale in the eastern portion of the tracts. Cooper's hawks are usually found in the river bottom, as would be expected of a bird predator. Golden eagles use the entire tracts. Owls nest along the river and feed in shadscale and sagebrush-greasewood. Downy woodpeckers are restricted to the trees along the White River. Common flickers are common on the river bottom but do use the upland juniper area.

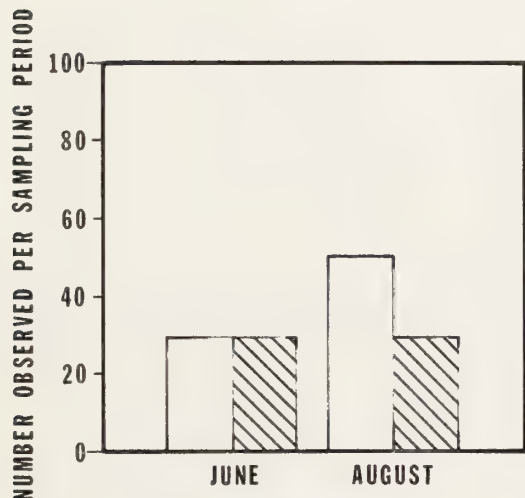
Horned larks are most common in the eastern portion of the tracts during the winter; a few nest in this area in the summer.



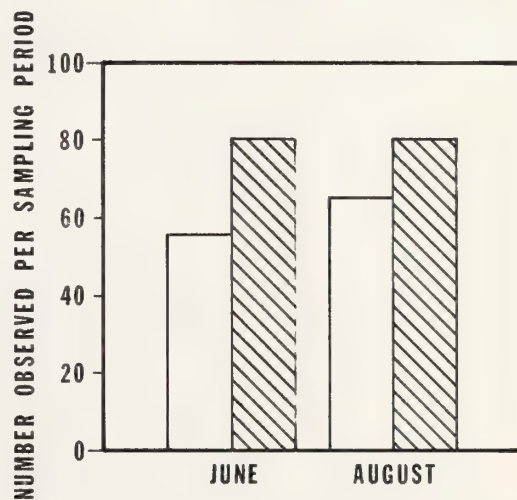
RIPARIAN



SAGEBRUSH/GREASEWOOD



SHADSCALE



JUNIPER

LEGEND

□ 1975 SIGHTING

▨ 1976 SIGHTING

REPTILIAN ABUNDANCE

BY MONTHS FROM TRANSECTS FOR FOUR VEGETATION TYPES

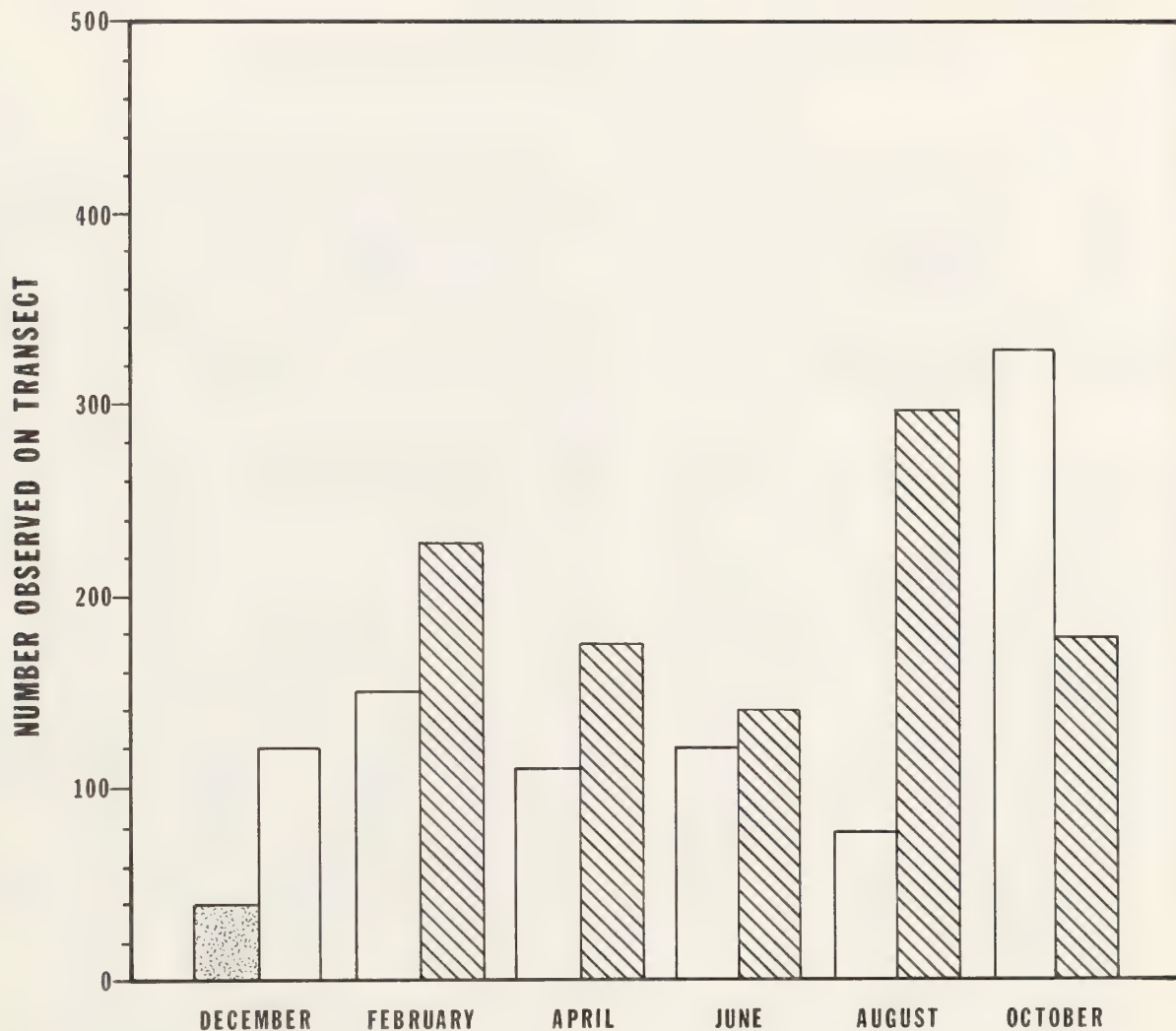
FIGURE IV-16



TABLE IV-34

PERMANENT AVIAN DISTRIBUTION AND ABUNDANCE

AVIAN PERMANENT RESIDENTS Order/Species	I. HABITAT DISTRIBUTION				II. ABUNDANCE	
	Occurrence per Total Sightings, %				Number Observed on Transects	
	Sagebrush- Greasewood	Juniper	Shadscale	Riparian	1975	1976
Falconiformes						
Marsh Hawk	64	0	91	18	4	1
Cooper's Hawk	44	33	22	67	3	2
Golden Eagle	100	92	100	83	20	20
Strigiformes						
Great Horned Owl	9	45	27	82	1	0
Piciformes						
Downy Woodpecker	0	0	0	100	13	18
Common Flicker (Red-shafted)	33	58	0	100	20	49
Passeriformes						
Horned Lark	42	42	100	25	184	298
Black-billed Magpie	83	92	83	100	61	93
Common Raven	54	54	64	54	7	40
Pinyon Jay	83	100	25	25	454	459
Plain Titmouse	27	91	0	9	18	42
Black-capped Chickadee	0	0	0	100	9	52
Loggerhead Shrike	83	8	83	42	32	54



LEGEND

1974 SIGHTING

 1975 SIGHTING

 1976 SIGHTING

PERMANENT AVIAN ABUNDANCE
 BY MONTH FROM TRANSECTS FOR PERMANENT RESIDENTS

Magpies are everywhere, as are the ravens. Pinyon jays, the nomads of the tracts, are particular to juniper and sagebrush-greasewood in and around Southam Canyon. The plain titmouse is especially particular to the juniper, as is the blackcapped chickadee to the river bottom. Loggerhead shrikes are most common in the shadscale and sagebrush-greasewood washes in the eastern area of the tracts. Pinyon jays and horned larks are the most abundant permanent residents, followed by magpies, loggerhead shrikes, and flickers.

Golden eagles were commonly observed throughout the tracts in 1975, and on one occasion, seven eagles were seen flock hunting. Although transect data suggest no change in the eagle population --20 were observed in 1975 and 20 in 1976--qualitative observations suggest otherwise. There were fewer mammals in 1975, and because of this in the winter eagles resorted to paired and flock hunting--team work rather than solitary hunting. The lack of prey necessitated movement, giving the impression of a sizeable eagle population from transects and other observations. In 1976 mammal populations increased drastically, decreasing the necessity for eagles to move. The same number of eagles were observed on transects that year, but few were observed moving throughout the tracts. From this study it is evident that assessing population change in large carnivores and herbivores on the tracts--snakes, eagles, and deer specifically --by movement may be a mistake during certain phases of population increase and decrease. When food is scarce, movement will increase and when food is abundant, movement will decrease. Without knowing about available cover, prey, and forage, estimates of large animal populations should be approached with caution, especially among the permanent residents.

There are twenty-three species of mammalian permanent residents --5 carnivore, and 16 rodent species, plus desert cottontails and mule deer. The rodents and rabbits are the most numerous and the most sampled. Rabbits were studied by transects, and rodents by trapping.

Species present and their distribution and activity periods are listed on Table IV-35. Few of the carnivores were actually observed on or off the transects. The presence of coyotes was determined by scats, tracks, and sound. Carnivore distribution and abundance data were too sparse to determine any trends.

Rodents are the most abundant mammals on the tracts. The numbers of rodents increased by 173% from 1975 to 1976 except for the golden-mantled squirrel, which decreased. Numbers of chipmunks, Apache pocket mice, and Ord kangaroo rats showed no increase from 1975 to 1976. All the other species increased.

Rodent distribution and abundance varied among the vegetation types. Whitetail antelope squirrels were found mainly in shadscale and sagebrush-greasewood, and a few squirrels were seen

TABLE IV-35

MAMMALIAN PERMANENT RESIDENTS, HABITAT DISTRIBUTION, AND ABUNDANCE

MAMMALIAN PERMANENT RESIDENTS Order/Species	I. HABITAT DISTRIBUTION				II. ABUNDANCE	
	Occurrence per Total Sightings, %				Number Observed and Captured on Transects	
	Sagebrush- Greasewood	Juniper	Shadscale	Riparian	1975	1976
Carnivora						
Weasel (Long-tailed)	X	0	0	X		
Striped Skunk	0	0	0	X		
Badger	0	0	X	X		
Coyote	55	55	44	55		
Bobcat	X	0	0	X		
Rodentia						
Whitetail Antelope Squirrel	100	83	100	0	47	63
Golden-mantled Squirrel	90	90	40	50	12	3
Least Chipmunk)	55	100	11	33	15	11
Colorado Chipmunk)						
Whitetail Prairie Dog	14	0	100	14		
Apache Pocket Mouse	100	100	88	75	51	52
Ord Kangaroo Rat	100	0	88	75 ^{1/}	22	29
Beaver	0	0	0	100	2	18
Western Harvest Mouse	100	33	33	33	3	9

^{1/} Evacuation Creek only.

TABLE IV-35 (CON'T.)

MAMMALIAN PERMANENT RESIDENTS Order/Species	I. HABITAT DISTRIBUTION				II. ABUNDANCE	
	Occurrence per Total Sightings, %				Number Observed and Captured on Transects	
	Sagebrush- Greasewood	Juniper	Shadscale	Riparian	1975	1976
Rodentia (Continued)						
Canon Mouse	0	100	0	0	14	27
Deer Mouse	100	100	88	100	200	352
Brush Mouse	0	0	0	X		
Pinyon Mouse	0	100	0	20	0	20
Desert Woodrat	70	100	30	30	16	49
Bushytail Woodrat	20	60	40	80	2	7
Muskrat	0	0	0	100		
Porcupine	0	9	0	100	3	30
Lagomorpha						
Desert Cottontail	100	92	100	92	207	976
Artiodactyla						
Mule Deer	83	83	92	92	23	31

X - presence - insufficient data or questionable observation

0 - absence

consistently in juniper. Golden-mantled squirrels were sagebrush-greasewood and juniper residents that invaded the riparian area in 1976. Least chipmunks and Colorado chipmunks could not be distinguished and so they are listed together. They are found primarily in juniper. A whitetail prairie dog town is in the northeast corner of the 1.6-km boundary area, north of the White River. Apache pocket mice, the smallest rodent on the tracts, and deer mice were found throughout the tracts. Ord kangaroo rats require the soil characteristics of the sagebrush-greasewood, shadscale, and Evacuation Creek areas. No kangaroo rats are found in the river bottomland. Beavers and muskrats are restricted, for the most part, to the river, although they will venture cross country on occasion. Western harvest mice, consistently found in sagebrush-greasewood, invaded the other vegetation types in 1976. Pinyon mice, and especially canyon mice, were restricted to juniper. The stick homes of desert and bushy-tail woodrats were found throughout the tracts, the former mainly in the juniper, the latter in the riparian. Most porcupines used the cottonwoods in the river bottom, although a porcupine was seen moving through the juniper.

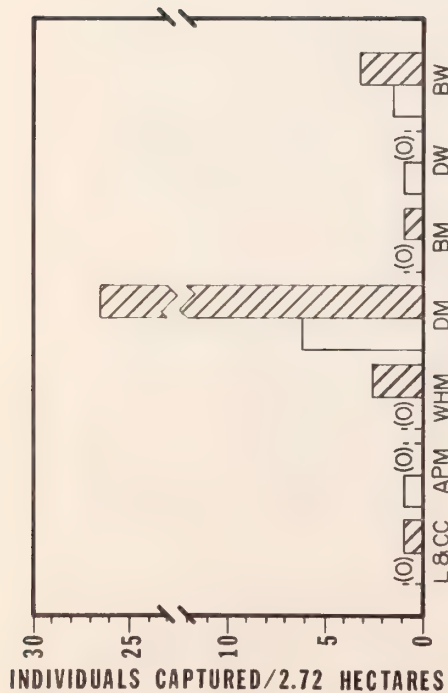
The rodent trapping grids, conducted each August, were used to determine distribution and density. Prior to this study, it was assumed that the river bottomland would support the most vertebrate species. This proved to be so for birds, but not for rodents--in fact, the lowest number of rodent species and the lowest densities were found on the river (Figure IV-18). This has little to do with available forage and seeds, which are dense. The controlling factors are the soil and water. The soils are primarily silts and clay, a not too permeable mixture that retains water. With the water from precipitation and the river, plus the cold inversions in the winter, the soil remains moist and freezes solid. The only areas where rodents were consistently captured were sand deposits.

At the highest elevations, densities in the juniper type were low from year to year (Figure IV-18), with a variety of species. Apparently juniper presents much habitat variation without much production.

It was initially assumed that the shadscale area would have the lowest productivity. This proved to be wrong. Deer mice went from 7/ha to 30/ha in one year, and the other rodent populations remained stable (Figure IV-18).

The sagebrush-greasewood type was thought to be the best habitat for rodents because of its deep soils, forage, and seed production. This assumption proved valid (Figure IV-18).

The rodents captured and their densities are presented in Table IV-36 by combining the results of the four trap grids.



RIPIARIAN

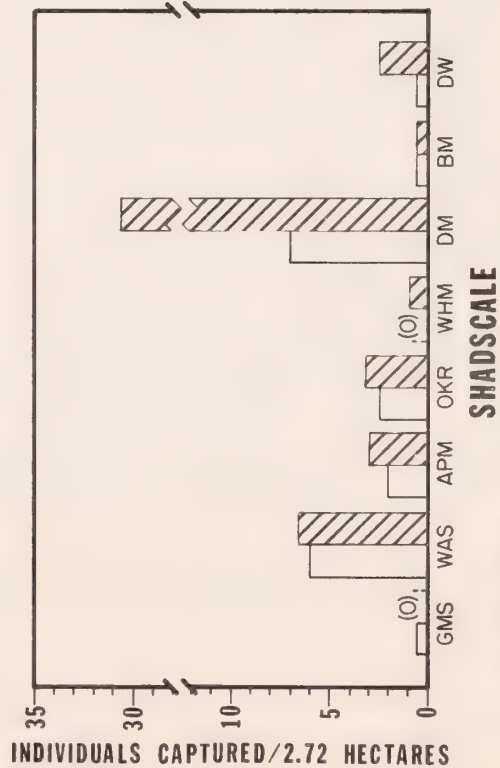
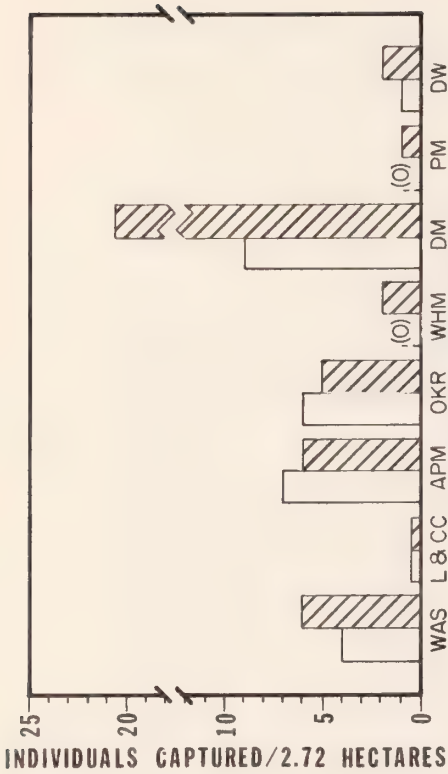
GMS - GOLDEN-MANTLED SQUIRREL
 WAS - WHITETAIL ANTELOPE SQUIRREL
 APM - APACHE POCKET MOUSE
 OKR - ORD KANGAROO RAT
 WHM - WESTERN HARVEST MOUSE
 L&CC - LEAST AND COLORADO CHIPMUNK

LEGEND

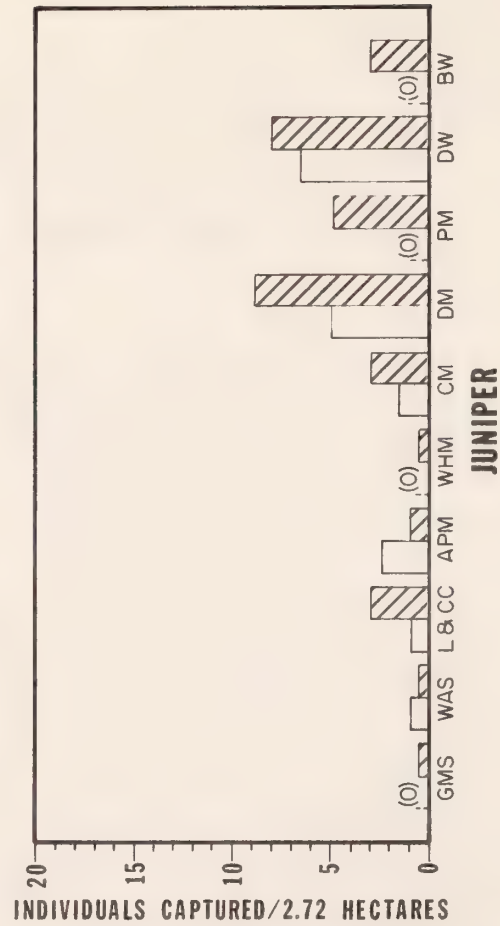
□ - 1975 COUNT
 ▨ - 1976 COUNT
 (0) - NO COUNT

DM - DEER MOUSE
 DW - DESERT WOODRAT
 PM - PINYON MOUSE
 CM - CANYON MOUSE
 BM - BUSH MOUSE
 BW - BUSHYTAIL WOODRAT

SAGEBRUSH/GREASEWOOD



SHADSCALE



JUNIPER

RODENT DENSITIES FROM TRAP GRIDS IN FOUR VEGETATION TYPES



TABLE IV-36

RODENT DENSITIES FROM FOUR TRAP GRIDS COMBINED

<u>RODENT SPECIES</u>	<u>1975</u>		<u>1976</u>	
	<u>Individuals Captured</u>	<u>Density No./hectare</u>	<u>Individuals Captured</u>	<u>Density No./hectare</u>
Golden-mantled Squirrel	1	0.1	1	0.1
Whitetail Antelope Squirrel	28	2.9	36	3.8
Least and Colorado Chipmunk	3	0.3	11	1.2
Apache Pocket Mouse	33	3.5	28	2.9
Ord Kangaroo Rat	23	2.4	23	2.4
Western Harvest Mouse	0	0	12	1.3
Canon Mouse	4	0.4	8	0.8
Deer Mouse	65	7.0	196	20.8
Pinyon Mouse	0	0	15	1.6
Brush Mouse	1	0.1	2	0.2
Desert Woodrat	22	2.3	33	3.5
Bushytail Woodrat	2	0.2	12	1.3
TOTAL	182	19.4	377	40.1

A mammal that rapidly exploits forage production is the desert cottontail. Comparing their abundance from transects, they increased 471% in one year (Figure IV-19).

Unclassified Users

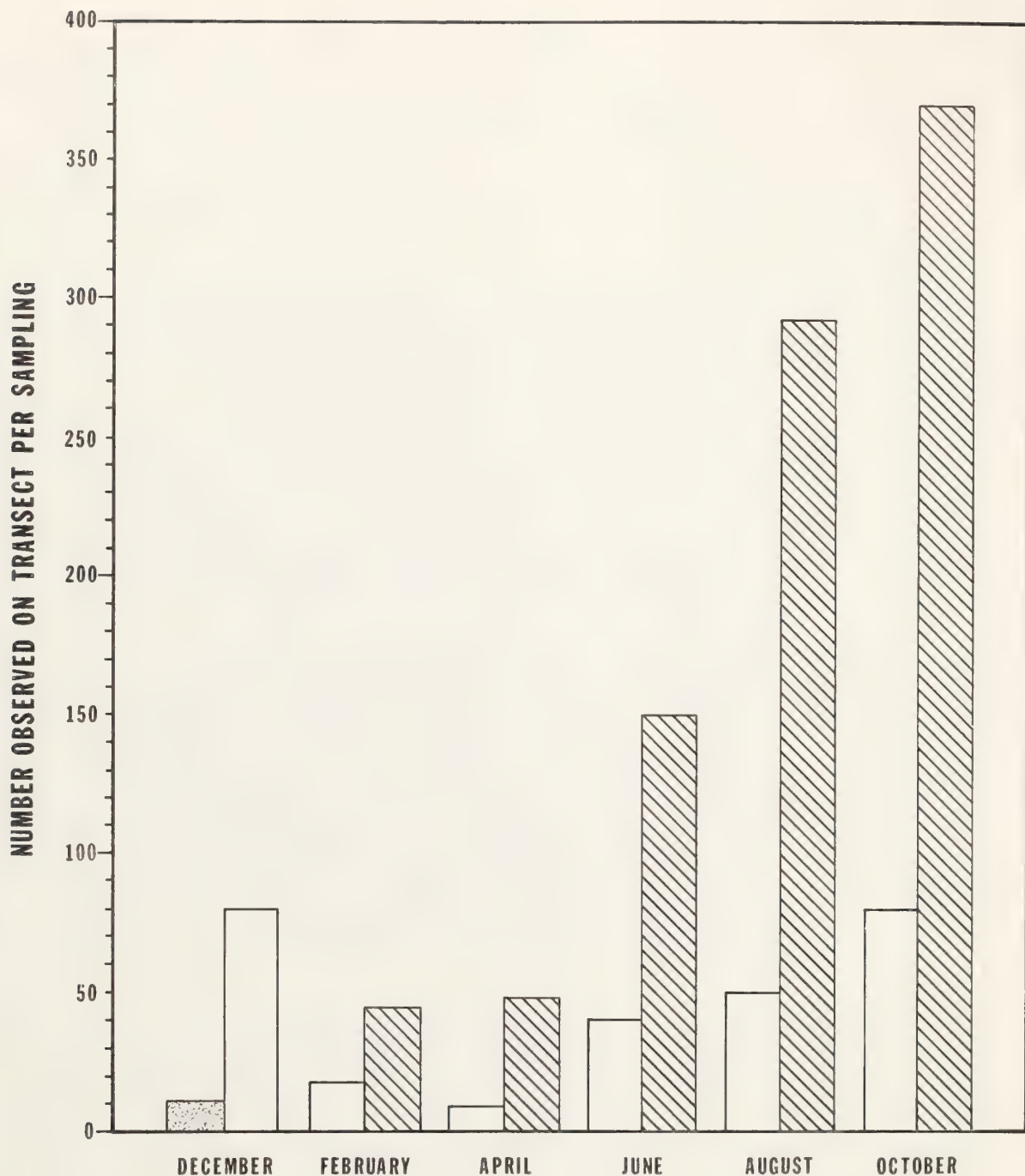
Twenty-six species of birds could not be classified in terms of use; either they were seen prior to this study and not again or they are classified but were outside the boundary (Table IV-37). Of the most concern are the eleven species seen on the tracts.

One of the species seen on the tracts during the transect walks was the endangered peregrine falcon, observed in April and August 1975. It is unclassified because it is not known whether the bird nested or just passed through the area. Being a bird predator, 1975 would have provided an ample food supply. A peregrine falcon was also seen off the tracts during the raptor survey conducted by DWR personnel (see Section IV. B. 2.e).

Four species are thought to be permanent residents--the sharp-shinned hawk, long-eared owl, hairy woodpecker, and scrub jay. Since the data do not support such classification, they remain questionable. The poor-will and red-eyed vireo are perhaps summer residents, and the canyon wren may be a winter resident. The eastern phoebe, tree swallow, and rose-breasted grosbeak are probably wanderers. Behle and Perry (1975) list these species as rare summer resident, common summer resident, and occasional, respectively. (Occasional means species that have been observed only three to five times in the past 50 years or only one time or not at all in the past 10 years. Occasional is a substitute for the older term "casual.").

Unclassified mammalian species numbered seven (Table IV-38). The olive-backed pocket mouse and northern grasshopper mouse were trapped by Perry (1975) on the tracts. Raccoons were identified by tracks (December 1974), a mountain lion was observed by four range biologists just north of the White River opposite the mouth of Southam Canyon (June 1975; refer to section IV. B. 2.b for additional information), and rock squirrels were seen by an aquatic biologist in Wagon Hound Canyon and in a side canyon of Hells Hole Canyon by a hydrographer (both observations in October 1976). The yellow-bellied marmot was seen in Asphalt Wash in August 1975 and again in April 1976. The black-tailed jackrabbit was seen in August and October 1976 in the southeast corner of the tract boundary area. The raccoons, marmots, and rock squirrels may all be permanent residents, and jackrabbits may be setting up residency. The mountain lion is most likely a transient from the Book Cliffs population.

The pocket mouse and grasshopper mouse were not captured during this study, and therefore their status as residents remains unconfirmed.



LEGEND



1974 SIGHTING



1975 SIGHTING



1976 SIGHTING



RABBIT ABUNDANCE FROM TRANSECTS THROUGH TWO YEARS

IV-110

FIGURE IV-19

TABLE IV-37

UNCLASSIFIED AVIANS' SPATIAL AND TEMPORAL DISTRIBUTION

UNCLASSIFIED AVIANS	I. HABITAT DISTRIBUTION AND LOCATION	II. TEMPORAL DISTRIBUTION
Order/Species		
Anseriformes		
Common Goldeneye ^{2/}		
Bufflehead ^{2/}		
Falconiformes		
Sharp-shinned Hawk	Shadscale, Riparian	Feb., Apr., 1976
Peregrine Falcon	Shadscale, Riparian	Apr., Aug., 1975
Galliformes		
Chukar ^{2/}		
Gruiformes		
Virginia Rail ^{1/}	Sagebrush-Greasewood, Southwest of tracts, Asphalt Wash Gas Pond	
Charadriiformes		
Least Sandpiper ^{2/}	Riparian	
American Avocet ^{2/}	Riparian	
Black-necked Stilt ^{3/}	Riparian	
Strigiformes		
Long-eared Owl	Riparian	Feb., Dec., 1975, Feb., 1976

TABLE IV-37 (CON'T.)

UNCLASSIFIED AVIANS Order/Species	I. HABITAT DISTRIBUTION AND LOCATION	II. TEMPORAL DISTRIBUTION
Strigiformes		
Burrowing Owl ^{1/}	Shadscale, East of tracts, near Colorado- Utah border	
Caprimulgiformes		
Poor Will	Juniper	Aug., 1975
Apodiformes		
Vaux's Swift ^{2/}	Riparian	
Piciformes		
Hairy Woodpecker	Riparian	Dec., 1975, Apr., Aug., 1976
Passeriformes		
Eastern Phoebe	Riparian	Oct., 1976
Tree Swallow	Riparian	June, 1975
Scrub Jay	Sagebrush-Greasewood, Juniper, Riparian	Dec., Feb., Apr., June, 1975, Aug., Oct., 1976
Canon Wren	Sagebrush-Greasewood, Juniper, Riparian	June, Dec., 1975, Feb., 1976
Bendire's Thrasher ^{1/}	Sagebrush-Greasewood, Shadscale, North of tracts, Coyote Basin	
Red-eyed Vireo	Riparian	June, 1975

TABLE IV-37 (CON'T.)

UNCLASSIFIED AVIANS Order/Species	I. HABITAT DISTRIBUTION AND LOCATION	II. TEMPORAL DISTRIBUTION
Passeriformes (Continued)		
Bay-breasted Warbler ^{3/}	Riparian	
American Redstart ^{3/}		
House Sparrow ^{1/}	North of tracts, at Bonanza, Utah	
Rose-breasted Grosbeak	Juniper	June, 1976
Lesser Goldfinch ^{1/}	Riparian, East of tracts White River	
Lark Bunting ^{1/}	Sagebrush flats, North of tracts, Dead Man's Bench	

^{1/}Observed off-tract, this study.

^{2/}Olsen, P. F. 1973. Wildlife resources of the Utah Oil Shale Area. Utah Div. Wildl. Res. No. 74-2. May or may not be on tracts.

^{3/}Behle, W. H. and M. L. Perry. 1975. Raptor study of Utah Oil Shale Area. In. Studies for Wildlife on Energy Areas. Utah Div. Wildl. Res. and Bur. Land Management. May or may not be on tracts.

TABLE IV-38
UNCLASSIFIED MAMMALS' SPATIAL DISTRIBUTION

UNCLASSIFIED MAMMALS OBSERVED ON TRACT Order/Species	II. HABITAT DISTRIBUTION			
	Sagebrush- Greasewood	Juniper	Shadscale	Riparian
Carnivora				
Raccoon				X
Mountain Lion	X		X	
Rodentia				
Yellow-bellied Marmot	X			
Rock Squirrel	X			
Olive-backed Pocket Mouse ¹	X			
Northern Grasshopper Mouse ¹	X			
Labomorpha				
Black-tailed Jackrabbit	X		X	

¹ Perry 1975

Data concerning species abundance, mean distance sighted, and frequency of sighting are listed for avian spring-summer residents in Appendix IV-1, for avian winter residents in Appendix IV-2, for avian transients in Appendix IV-3, for avian permanent residents in Appendix IV-4, for unclassified avians in Appendix IV-5, and for seasonal and permanent mammals in Appendix IV-6. Abundance (captures/100 trap nights and recaptures/100 trap nights) from transect trapping are listed by species in Appendix IV-7. Each common name listed is accompanied by its taxonomic counterpart according to Behle and Perry (1975) for birds, and Armstrong (1972) for mammals.

c. Interpretation and Conclusions

A main factor in vertebrate use in terms of species composition and abundance is the importance of the White River, Evacuation Creek, Hells Hole Canyon, and Asphalt Wash. These are avenues of ingress and egress for many of the vertebrates. The river is also a refuge and a necessity to many bird species and to mule deer, beavers, muskrats, porcupines, coyotes, racers, garter snakes, tree lizards, and frogs and toads.

A second factor is what these data suggest in terms of perturbation and change on the tracts. The spring of 1975 was cold and wet--wet enough to bring about a desert bloom. Plant growth was considerable. The spring of 1976 was warm and dry. Flowers, insects, and birds were fewer. Of interest is the precipitation pattern for years. No more total moisture fell in 1975 than in 1976. The difference was moisture distribution. Snow persisted from winter into spring in 1975, but it was warm with little snow by late February in 1976. The permanent residents' increase is apparently keyed to the seed and forage production from the bloom.

The seasonal users, especially the birds, appear to be indicators of immediate environmental change. With the desert bloom came the summer birds, and with the seed production came the winter birds. An example is the June-to-August avian decrease. The insectivorous birds and some herbivorous birds leave the tracts sometime in July, even though insects and seeds are still available in August. One reason may be when summer heat, winds, etc. lead to plant desiccation and drying up of most water sources. Another reason may be activity of young-of-the-year and yearlings. Whatever the reason, the value of the seasonal users to biological impacts is that their changes in species composition, distribution, and abundance are keys to changes within the immediate area.

Rabbits and rodents are also a key to biological impacts in that they reflect the extent of seed and forage production and climatological factors on the tracts. During the study they

reflected the magnitude of change a year after the bloom, confirming the extent of the desert bloom and what was observed in the seasonal birds. Lizards, on the other hand, seemed less affected by yearly environmental variations. It is likely that should the reptiles significantly increase or decrease, the environmental change would be major and, most likely, long-lasting.

d. Evaluation of Baseline Program

The following evaluation of this study was based upon the review of work done in fulfillment of applicable federal oil shale lease requirements. This work consisted of assessing five components of terrestrial vertebrate populations: 1) species inventory; 2) spatial distribution; 3) temporal distribution; 4) densities; and 5) ecological relationships.

The five components have been conditionally met in the two-year baseline. The conditional factor is that biological information is subject to time in terms of reliability. Reliability necessitates continuity in technique, sampling periods, and annual monitoring. The two-year baseline is unique in the sense of beginning a complete environmental assessment.

Within these two years the inventory and distribution components (spatial and temporal) furnished a sound data base for comparison of presence/absence of species in habitat types and seasonal occurrence. Among all the species observed, the most important in terms of indicators within specific habitats are the permanent residents. Loggerhead shrikes, Ord's kangaroo rats, and desert short-horned lizards are specific to shadscale and sagebrush-greasewood vegetation. Plain titmice, pinyon jays, and canyon mice are specific in juniper vegetation. Blackcapped chickadees, downy woodpeckers, beaver, and porcupines are specific to the riparian vegetation. The presence of these species has been consistent throughout the monitoring program. Some other permanent residents are indicators of tract-wide change in that they are found in all habitat types, e.g., deer mice, apache pocket mice, golden eagles, black-billed magpies, and sagebrush lizards.

The density component could not be defined as well as the inventory and distribution components. The densities are beyond the state of the art for currently available biological techniques. The data collected is sufficient to indicate population shifts or the lack of a shift from 1975 to 1976, e.g., increase in cottontails and some rodents, decrease in seasonal birds, and stability in the reptiles. The ecological relationships of the vertebrates, as represented by the above four components, are augmented by general data from the other disciplines that studied the tracts.

With this information and using seasonal and permanent residents as guides to immediate and long-term change, respectively, the vertebrate baseline monitoring provides a sound foundation for examining and searching for impacts from mining development, operation, and reclamation. All these factors (inventory, distribution, density, and relationships), therefore can be used to be most indicative of impacts that cause divergence from the natural order of vertebrate populations.

2. SPECIAL STUDIES

As a supplement to the general sampling program described in Section IV.B.1, special studies were initiated to monitor vertebrates not amenable to a scheduled monitoring program. The species studied were the economically important and/or sensitive vertebrates, including deer, cottontails, mourning doves, predators, raptors, waterfowl, beaver, and livestock. Also, an opportunistic sampling program was conducted for amphibians and reptiles. The vertebrates studied were monitored to determine their movements, areas of use, seasons of use, and productivity.

a. Mule deer, Antelope, and Elk

Methodology

Mule deer were studied to determine their activity and productivity on the tracts. The study included determining fawn-to-doe ratios; conducting telemetry studies; performing aerial trend counts; measuring pellet group and browse use transects; and interviewing hunters to determine hunting pressure. The results of these studies were used in conjunction with data collected by the Utah Division of Wildlife Resources (DWR) in deer herd Unit 28A to characterize regional mule deer activity. A specific program was not developed to study antelope or elk on the tracts; instead, their identity, location, and activities were recorded opportunistically.

The ratio of fawns to does was determined as an indication of deer productivity on the tracts (Cowan 1950; Robinette and Olsen 1944). The method used is described in the Partial Exploration Plan. Since this method is used in all deer-management units in Utah, the productivity data can be compared with those from other deer herds in northeastern Utah as well as the rest of the state.

The telemetry program was conducted to determine patterns of use and key use areas. The study involved selecting certain deer and fitting them with collars containing radio transmitters operating at different frequencies.

The aerial trend count study was conducted in 1975 but was discontinued in 1976 because of the lack of snow, which limited the ability to observe deer. Information from the first year of study is included in the First Year Environmental Baseline Report (FYEBR).

Deer-harvest data were collected for the area by contacting hunters during the 1975 and 1976 deer seasons. Roadblocks were set up during the opening weekends of the two seasons at Ignacio, where hunters leaving the area could be easily contacted. In addition, individual camps and hunting parties were contacted during the course of the two seasons. Information collected during hunter interviews included the number of individual hunters, number of deer harvested, and age of harvested deer. Ages were determined using the tooth wear and replacement method. Since hunting is limited to buck permits in the project area, only males were available for aging.

A series of pellet-group transects--both swept and random--was established on the project area in late May and early June 1976 to indicate areas and intensities of use by mule deer. Swept pellet transects were constructed by driving stakes at 14-m (45-ft) intervals along each transect in the survey area. A circle with a 1.7-m (5.6-ft) radius from each stake was cleaned of all old pellets to give a swept area of 9.29 sq m (100 sq ft). Transects were laid out in series of 25 or 50 plots that were relatively permanent for annual comparison of data. A total of 125 plots were placed in each of the 4 vegetation types of the project area.

Random transects involved traversing an area on a straight line course and stopping every 15 paces to count pellet groups within a 1.7-m (5.6-ft) radius of the observer. Only pellet groups of the preceding winter were counted, and the transects were not swept. A series of 1200 plots (12 transects of 100 plots) was completed--300 in each vegetation type.

The browse use study was conducted to sample deer use in each vegetation type. The methodology used (Cole 1958 and 1963) is described in the Partial Exploration Plan. The percentage of browse use was determined by a visual estimate of the current year's growth compared with the growth available.

Summary of Results

Approximately 150 to 250 mule deer actively use the tracts in the summer, spring and fall. Approximately 50 to 100 mule deer utilize the area in the winter. Antelope and elk apparently do not use the tracts at all. During the study, neither species was seen on the tracts, and elk were not even seen in the vicinity. In 1975 groups of antelope were seen twice in areas north of the tracts: on November 4, 1975, twenty-one antelope were sighted about 1.8 km due north of Station F-5, at the mouth of Asphalt Wash; and on December 5, 1975, forty-two antelope were sighted 1.6 km northeast of Station A-3, north of Tract U-a.

The tracts are encompassed by deer herd Unit 28A, which is bounded on the south by the north-south drainage divide of the Book Cliffs, on the east by the Colorado state line, on the north by U.S. Highway 40, and on the west by the Uintah-Ouray Indian Reservation.

Although the DWR has conducted deer classification studies (doe-to-fawn ratios), pellet group counts, and browse use transects in Unit 28A, all were conducted far to the south, in the higher elevations. For this reason, data from these studies are not directly applicable to conditions on the tracts, which are in the lower elevations of the unit; however, the DWR data were used in conjunction with that collected in the baseline program as an indication of regional mule deer activity.

Historically, Unit 28A has been one of the most popular and productive deer hunting areas in the state. During the late 1950s and early 1960s, large numbers of trophy deer were taken, with annual harvests of approximately 2500 deer for several years. During the 1960s, the DWR and BLM initiated a program of range restoration, and deer numbers were reduced until a low was reached around 1974, during which only 543 deer were harvested. Since that time, the management program of the DWR has been to restore deer numbers to the carrying capacity of the range. In 1975 the harvest increased to 850 buck deer (45% hunter success). The harvest figures for 1976 are not yet available.

It has long been known that an area of deer concentration has existed along the White River corridor on the tracts. Local hunters using these areas have reported excellent deer hunting in the past; however, prior to initiation of this study, very little was actually known of the conditions affecting the White River deer herd or of the dynamics of the population.

In August 1969 stockmen running cattle on the White River reported to the local DWR office that deer were dying in large numbers along the river. At this time, deer were reported to be extremely numerous in the area. Local biologists surveyed the area using horses and reported finding numerous recently-dead deer. Because of the remoteness of the area and the hot weather, samples fresh enough to isolate a pathogen could not be obtained, and no disease was identified; it was felt, however, that some epizootic had run through the deer concentrated along the White River. In subsequent years, it was found that deer numbered only a small fraction of pre-1969 levels.

Deer Classification: Table IV-39 lists the results of deer classification studies in 1975 and 1976. The data indicate that productivity was relatively constant during both years, both on the tracts and in the rest of Unit 28A.

TABLE IV-39
DEER CLASSIFICATIONS

Year	Project Area				Herd Unit 28A *			
	Fawns	Does	Bucks	Fawn:Doe	Fawns	Does	Bucks	Fawn:Doe
1975	52	64	3	81%	116	168	53	69%
1976	84	116	16	72%	179	234	48	76%
Ave.	136	180	19	76	295	402	101	73

*exclusive of project area data.

Telemetry: During 1976 radio-collared deer were monitored from March through August to determine activity patterns. Four animals were successfully located during this period: three were does collared in December 1976. Table IV-40 lists all sightings made during this time.

The results of the 1975 program are described in the FYEBR. In general, during both years the deer left the lower elevations during the coldest part of the winter and resumed residence on the White River in March. Three does that had spent the previous year on the river were located in almost exactly the same areas in March 1976.

Two does (.09 and .06) were consistently monitored throughout spring and summer 1976. The pattern of sighting (Figure IV-20) shows a definite area of preferred usage by these two animals.

The third doe (.02) was not located after the end of April, due undoubtedly to radio failure. One buck (.17) was monitored through August 1976. As in 1975, the pattern of sightings for this buck was much more dispersed than for the does, and much more time was spent in upland areas away from the river. Only 7 of the 14 (50%) sightings of this buck were in riparian areas, whereas most of the doe sightings, 41 of 44 (93%), were in these areas. Only two sightings, both bucks, were in juniper, and no sightings were made in greasewood.

On three occasions during summer 1976, deer were monitored for a full 24-hour day. Doe .06 was monitored twice and doe .09 once. Except for a 4-hour period when doe .09 could not be located, no unusual movements were observed. In each case, the riparian areas normally used by each deer were used throughout the period.

The following is a summary of telemetry activities for each collared deer:

Deer .06 was collared on May 5, 1975, approximately 0.4 km to 0.8 km downstream from the pipeline crossing the White River near the mouth of Evacuation Creek. This individual, a mature doe, was fitted with a radio collar and a white neck band.

During the summer (June, July, and August) this deer was consistently located along a limited area of riparian habitat immediately above and below the pipeline crossing. On a few occasions, it could not be located for short periods (i.e., a few days). Although this deer was not observed away from the river area, it is probable that these short periods of absence were spent in the rugged canyons adjacent to the river corridor where shade and escape from insects were available. It was seen to have twin fawns in June, and these remained with it until fall.

TABLE IV-40
RADIO SIGHTINGS OF DEER BY VEGETATIVE TYPE
1975-1976

DEER	Riparian		Shadscale		Juniper		Sagebrush-Greasewood	
	1975	1976	1975	1976	1975	1976	1975	1976
.01	3	0	0	0	0	0	0	0
.02	7	6	2	0	1	0	0	0
.05	11	0	0	0	0	0	0	0
.06	17	23	0	0	0	0	0	0
.07	4	0	0	0	0	0	0	0
.09	6	12	2	3	0	0	0	0
.17	0	7	0	5	0	2	0	0
TOTAL	48	48	4	8	1	2	0	0

Radio sightings of this deer were continued through December, at which time deer began to leave the White River area, moving into the higher elevations adjacent to the tracts. After that, no sightings were made until March, when the deer was located on the White River in the same area it had occupied the previous summer. During the succeeding months (March through August) deer .06 again showed a consistent pattern of use in this portion of the White River riparian habitat. One visual sighting was made in April. At that time it was in the company of four uncollared deer. No additional visual sightings were made, so no indications of fawn production were observed.

Twenty-four-hour monitoring of deer .06 was conducted on two occasions during summer 1976. On both occasions, no discernible movements could be detected. It is probable that for much of the summer, all the requirements of food, water, and cover were met in a limited area, and little travel was required.

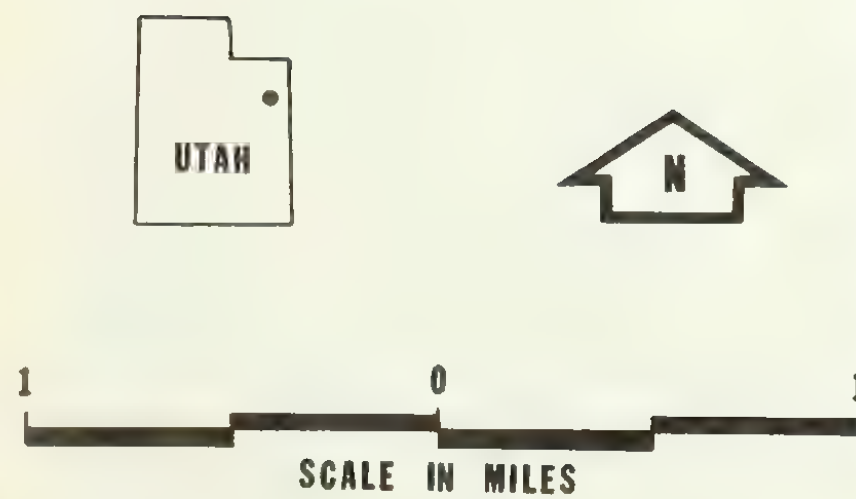
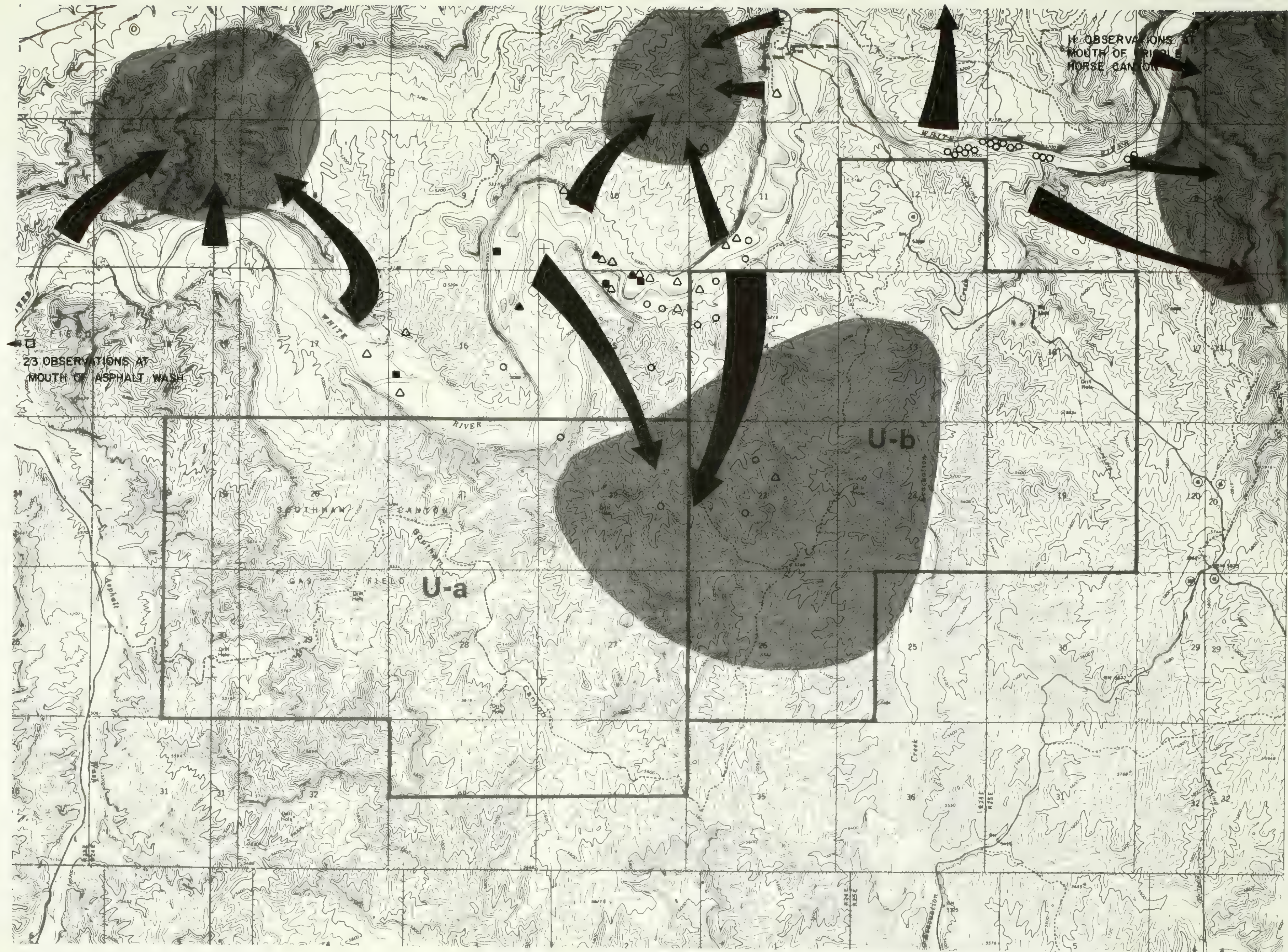
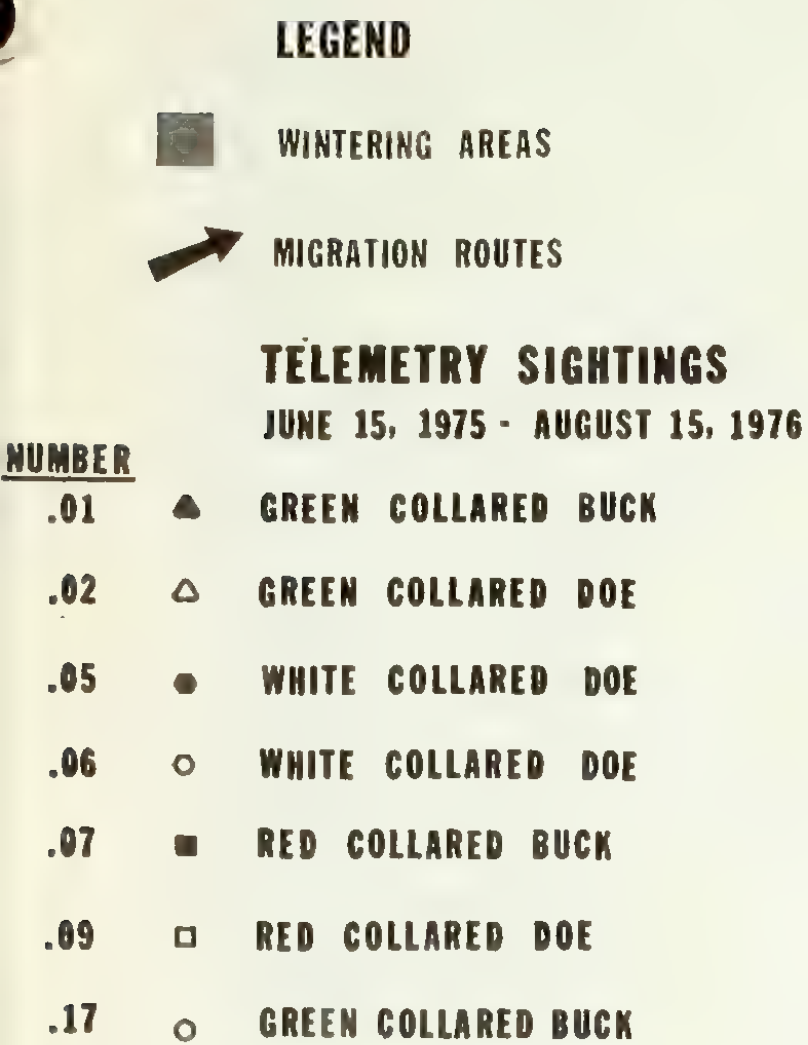
The last radio sighting of deer .06 was in late August 1976, within a few hundred meters of the point where it had been captured 16 months previously. No observations were made after this time, probably due to radio failure. The deer was located 39 times during the study, always in the riparian habitat and always within a 0.65 sq km (0.25 sq mi) area along the White River.

Deer .09, a mature doe, was collared on May 6, 1975, in the riparian habitat 0.8 km upstream from the mouth of Asphalt Wash. As with doe .06, this doe maintained a consistent pattern of use in the riparian area immediately upstream from the mouth of Asphalt Wash on the White River. Throughout the summer and early fall, it was located easily in this area. Two visual sightings were made during this period, and on one of these two fawns were seen with it. No subsequent sightings were made during the study period to determine fawn survival.

When the December trend count was conducted in 1975, there were sheep throughout the western portion of the tracts. Deer were few, having apparently left the area, and deer .09 was not observed.

By late March 1976, deer .09 had returned to the White River area where it had spent the previous summer. A visual sighting was made at this time in an area approximately 180 m (600 ft) from where it was captured 11 months previously. There were two additional deer with the collared doe, which appeared to be last year's fawns.

From March through September 1976, this deer maintained a consistent use pattern in the area of the White River it had frequented during summer 1975. One 24-hour monitoring session was conducted in mid-July. The deer remained in a limited area of



**DEER MIGRATION ROUTES, WINTERING AREAS,
AND TELEMETRY SIGHTINGS**

the river, except for a four-hour period when it could not be located. In the morning, however, it had returned to its previous area of use. It is probable that it had moved into one of the rocky side canyons along the river, where radio signals were obstructed.

One visual sighting of this deer was made after the time when fawns normally would be following. At this time, July 13, 1976, it was accompanied by twin fawns. No visual sightings were made after this time. Radio sightings were made through August 1976, after which none could be obtained. It is probable that the radio unit had ceased functioning. This doe was located 23 times during the study, 18 times (78%) in the riparian areas and 5 times in shadscale. All sightings were within an area of approximately 1.3 sq km (0.5 sq mi).

Deer .05 was captured on May 6, 1975, along the White River 0.4 km upstream from the mouth of Hells Hole Canyon. It was a mature doe, and appeared pregnant.

When first located by telemetry, it had moved to the riparian area along the White River at the mouth of Cowboy Canyon, several kilometers upstream from Hells Hole Canyon. During summer 1975, it remained exclusively in this area, with no subsequent movements.

This deer was sighted twice during summer 1975. In one sighting in July it was accompanied by at least one fawn. The dense vegetation in the area may have obscured a second fawn from view.

Deer .05 was monitored throughout summer and into fall 1975. It was last sighted in November of that year, at which time it was in the same area it had spent the summer. During the December trend count in 1975, a white collared deer, probably deer .05, was seen in the uplands south of the White River between Cowboy Canyon and Hells Hole Canyon. The deer was part of a group of 16, and therefore the number of fawns with it could not be determined.

No radio locations of this deer were made during 1976 despite extensive on-ground and aerial searches. The deer had either left the area completely or the radio had ceased functioning. A total of 11 sightings were made during the study, all in the riparian habitat and all within an area of approximately 1.3 sq km.

Deer .02 was captured on May 5, 1975, in the riparian area of the White River, 0.8 km below the Ignacio bridge. It was a mature doe, and appeared pregnant.

Of the four does monitored during the study, deer .02 showed the least tendency to remain in a particular area for extended periods. Sightings during summer and fall 1975 and spring and summer 1976

showed a more diffuse pattern of use than that exhibited by the other does; however, the sightings were still largely limited to the White River corridor along a stretch of several kilometers of river. Of all the sightings made during the study, 81% were in the riparian habitat of the White River.

No visual sightings of deer .02 were made during summer and fall 1975. When the December 1975 trend count was conducted, deer .02 was seen with two fawns on the White River above Southam Canyon. Two days later, she was located again in the uplands north of air station A-11. As described in the FYEBR, deer were actively moving into higher elevation wintering areas at this time. This upland observation of a deer collared in the riparian offered good validation of this phenomenon. At this time, one of its fawns, a male (.17), was captured and fitted with a radio collar and a green neckband.

During mid-winter (January and February) 1976, no sightings were made of doe .02. By early March, however, it had returned to the White River riparian area, in the general area occupied the previous year. No visual sightings were made during spring and summer 1976. Radio sightings were frequent enough to determine that it was again resident in the White River riparian habitat east of exploration drill hole X-2. No radio locations were obtained after April of 1976, probably because of radio failure. During the study, a total of 16 radio locations of this deer were obtained. If the sighting of deer .02 made near Station A-11 is excluded, the remaining sightings are included in an area of approximately 2.6 sq km (1 sq mi).

Deer .17, the male fawn of doe .02, was captured on December 16, 1975, during the December trend count. It was captured north of A-11 in juniper vegetation, although it was observed two days previously near Southam Canyon on the White River.

Beginning in March, this deer was monitored through the spring and summer. The movements of this male were quite different from those of the does: exactly half of the sightings of this buck were in vegetation types other than the riparian over a much wider range, about 10.4 sq km (4 sq mi), with many sightings in upland areas away from the river. As discussed previously, it is felt that this relative independence from the riparian habitat is characteristic of male deer.

Deer .07, a yearling male, was collared on May 7, 1975, 0.4 km downstream from Station S-4 on the White River. Efforts to monitor this animal met with little success compared to the results obtained from most other deer. It was sighted only four times during summer 1975. With the long period of time between each sighting (only four in four months), it is probable that this animal spent a considerable percentage of its time away from the tracts. All four of the successful sightings were in the riparian along a 6.4-km (4-mi) stretch of the White River. As with male deer .17, it appears that the males are not strongly dependent on the White River during this period.

A visual sighting of deer .07 was made during the 1975 deer hunt by a deer hunter. After an interview, it was strongly suspected that the hunter had harvested the animal when he described in detail the collar and radio on the animal. However, he would not admit to killing it. This animal was not located again after this incident.

Deer .01, a yearling male, was captured on May 5, 1975, near X-2 on the White River. As with deer .07, there was little success in monitoring this deer. Only three sightings were made during summer 1975, all in the riparian type along a 2.4-km (1.5-mi) stretch of the White River. The radio signals obtained when sightings were made were clear and strong, and it was felt that the radio was functioning properly. It is concluded that this male, like the others, spent much of its time in areas away from the project area. Contacts with deer hunters during the 1975 and 1976 deer seasons revealed no sightings of this deer. From field contacts, it seems evident that this animal was not harvested, but instead may have moved to some other area.

Extensive field contacts were made with hunters in the area during the 1976 hunting season to determine if there was any harvest of collared deer. Though at least 15 harvested deer were observed, none were collared and no collared deer were reported by hunters as having been harvested.

Hunting Pressure: Tables IV-41 and 42 summarize the data gathered during the 1975 and 1976 deer hunts. Because of the relatively small sample size, life tables from age data were not made. The large percentage of yearling bucks in the harvest was expected because of the high recruitment of young animals into this herd unit.

Hunters were more successful in 1976 than in 1975. On the tracts, success increased from 13.8% to 26%, while success in the rest of the unit increased from 13.6% to 19%. Total kills on the project area increased from 11 in 1975 to 15 in 1976. Harvest figures for Unit 28A are not available for 1976, so no comparison could be made. Hunting pressure on the project area remained constant for the two years; however, in 1976 pressure decreased in the rest of Unit 28A.

Pellet Group Transects: Tables IV-43 and 44 summarize pellet group counts as determined from 1976 transects (Figure IV-21). Table IV-45 lists use according to vegetation type. The specifications and conversion factors used to calculate deer days use per acre are illustrated in the sample computation (Table IV-46). Deer days use per acre is the equivalent of one deer spending one day on an acre plot of ground.

Browse Use Transects: During April and May, a series of extensive browse use transects (Cole 1959) were completed (Figure IV-21).

TABLE IV-41
DEER HARVEST STRUCTURE

Age Class	1975	1976
Yearling	6	9
2-1/2 Years	1	1
Mature (Older than 2-1/2 Years)	3	2
TOTAL	10	12

TABLE IV-42
HUNTER SUCCESS

Year	Tracts			Unit 28A			Combined		
	Hunters	Deer	Success	Hunters	Deer	Success	Hunters	Deer	Success
1975	58	8	13.8%	140	19	13.6%	198	27	13.6%
1976	56	15	26%	84	16	19%	140	31	22%

TABLE IV-43
SWEPT PELLET TRANSECTS

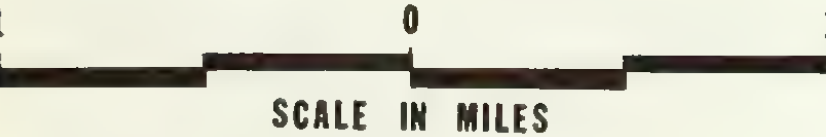
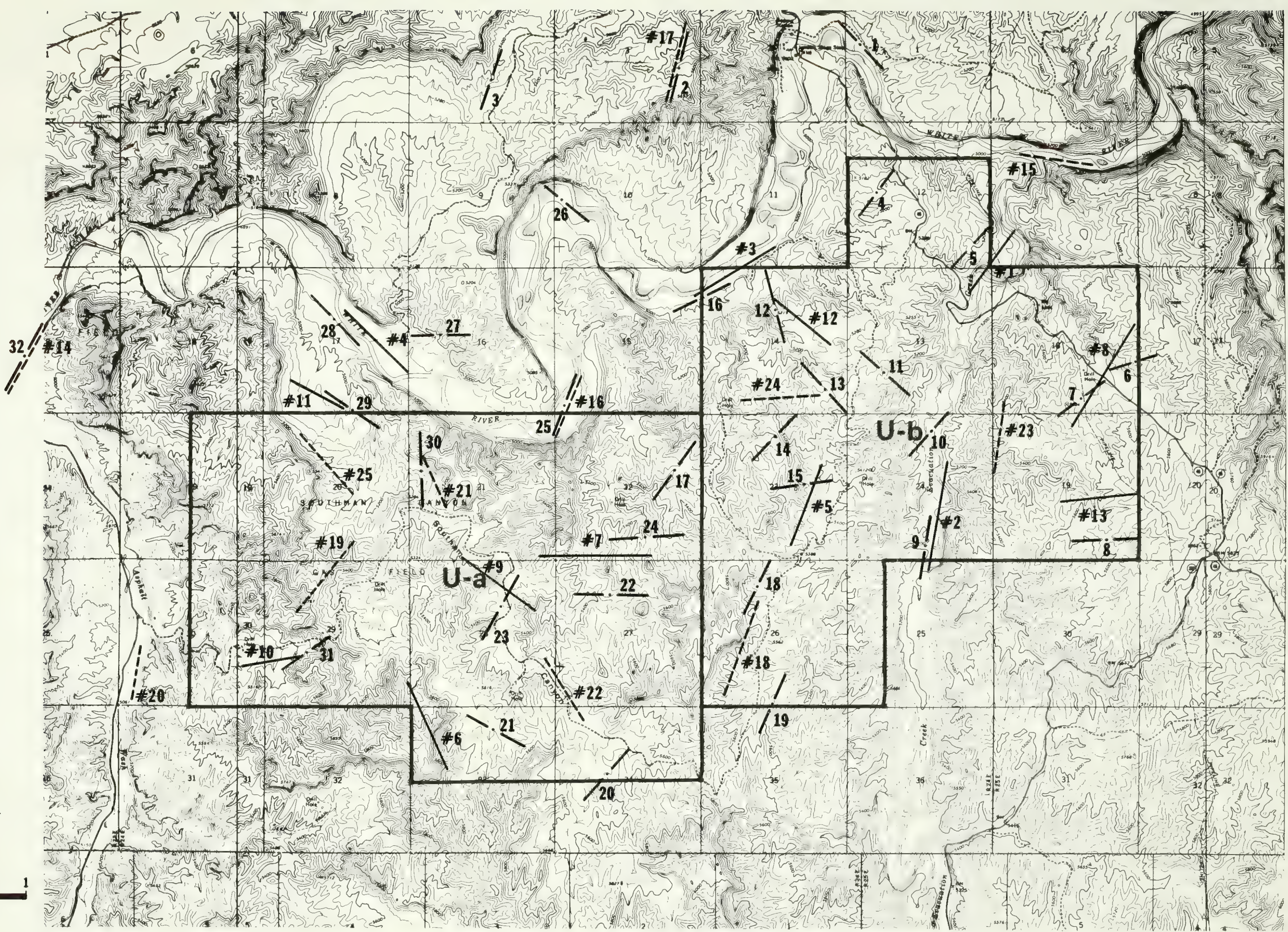
Location		Type	No. Plots	Deer Days Use/Ac.
1	Evacuation Creek	Riparian	50	6
2	G-18	Riparian	25	4
3	X-2	Riparian	25	2
4	PP-12	Riparian	25	1
5	X-5	Juniper	50	3
6	X-10	Juniper	25	1
7	PP-10	Juniper	50	0
8	PP-17	Sagebrush-Greasewood	50	0
9	X-11	Sagebrush-Greasewood	50	0
10	PP-4	Sagebrush-Greasewood	25	0
11	PP-5	Shadscale	50	0
12	PP-19	Shadscale	50	2
13	P-4	Shadscale	25	0

TABLE IV-44
RANDOM TRANSECTS

Location		Vegetative Type	Deer Days Use/ Acre
14	F-5	Riparian	2
15	F-2	Riparian	5
16	F-4	Riparian	4
17	Ignacio Highlands	Juniper	4
18	P-3	Juniper	2
19	PP-7	Juniper	1
20	PP-3	Sagebrush-greasewood	0
21	G-2	Sagebrush-greasewood	0
22	G-15	Sagebrush-greasewood	0
23	X-6	Shadscale	0
24	X-4	Shadscale	1
25	HS-4	Shadscale	0

LEGEND

- RANDOM TRANSECTS
- SWEPT TRANSECTS
- .- COLE BROWSE TRANSECTS



COLE BROWSE, RANDOM AND SWEEP PELLET TRANSECTS

FIGURE IV-21

TABLE IV-45

UTILIZATION BY VEGETATION TYPE

Vegetative Type	No. Transects	No. Plots	Deer Days Use/Acre
Riparian	7	425	3.7
Juniper	6	425	2.1
Greasewood-sagebrush	6	425	0
Shadscale	6	425	0.5

TABLE IV-46
 PELLET GROUP COUNT

Size Plots: 100 sq ft

No. Plots: 25

No. Pellet Groups: 3

*Comp. Factor x No. Pellet Groups = Deer Days Use/Acre

1.34 x 3 = 4.02

Deer Days Use/Acre: 4

Remarks: Transect G-18 Riparian

Table for use only with 100 sq. ft. size plots:

<u>No Plots</u>	<u>Comp. Factor</u>
25	1.34
50	.67
60	.558
70	.48
80	.42
100	.335
120	.279
140	.239
150	.223
200	.167
250	.134
300	.111
400	.084
500	.067
1,000	.034

*Computation Factor has been computed so that this factor multiplied by number of pellet groups will give deer days use/acre. Use the Comp. Factor corresponding to the number of plots taken.

A total of 32 transects, 8 in each vegetation type, were conducted. The species used in these studies were sagebrush (*Artemisia*) and greasewood (*Sarcobatus*) because they are found in various areas of each vegetation type on the tracts. Sagebrush is a staple forage species for deer and livestock, and greasewood is a staple winter food for sheep. It was felt that use data for these species would indicate levels of relative use by livestock and deer in the various areas of the tracts.

Tables IV-47 and 48 list the levels of use in each vegetation type. The most heavily used vegetation type was sagebrush-greasewood. This type is characteristic of the bottoms of the larger washes and canyons of the project area and is typically a preferred area for wintering sheep. The average use of sagebrush and greasewood in this type was 21% and 34%, respectively.

Riparian and shadscale, although very different, were used about equally. Levels of sagebrush and greasewood use were 11% and 23% in shadscale and 12% and 24%, respectively, in riparian types. These levels are midway between the levels of the other two vegetation types. The fact that the levels of use are percentages of the previous year's growth used is not evident from the data, but is inherent in the methodology of Cole transects. Thus, a 24% utilization of greasewood in the riparian area, where production of vegetation is high, would be a much larger amount of forage consumed than would be a 24% level of use in the shadscale, a more xeric and unproductive type.

Interpretation and Conclusions

Deer Classification: Productivity in desert mule deer populations is usually low. The does are dependent on adequate grasses and succulent forbs for milk production, and since desert communities are generally poor in these forage types, fawn production is often low.

The tracts are unique as a desert area. Vegetation covering most of the area is xeric with very little succulent vegetation, but the riparian areas flanking the White River furnish a habitat abundant in forbs and grasses, water, and escape cover. As described in the telemetry studies, does spend almost the entire fawning and nursing periods along the White River corridor. Because it is the only suitable fawning habitat available, this area is crucial to deer productivity on the tracts.

The average production figure during the study (76%) indicates good recruitment of fawns into the herd. The higher elevations in the southern part of Unit 28A had a 73% fawn crop during this time.

TABLE IV-47
COLE TRANSACT DATA

Site	Vegetative Type	Use: <i>Artemisia</i>	<i>Sarcobatus</i>	Remarks
1	Riparian	8%	41%	Heavy Sheep Use
2	Juniper	4%		Low Sheep Use
3	Shadscale	1%		Low Sheep Use
4	Shadscale	10%	25%	Moderate Sheep Use
5	Shadscale	16%	23%	Moderate Sheep Use
6	Shadscale	3%		Low Sheep Use
7	Shadscale	5%		Low Sheep Use
8	Shadscale	2%		Low Sheep Use
9	Riparian	14%	32%	Heavy Sheep Use
10	Riparian	14%	2%	Low Sheep Use
11	Sagebrush-greasewood	31%	30%	Heavy Sheep Use
12	Shadscale	17%		Moderate Sheep Use
13	Juniper	47%		Heavy Sheep Use
14	Juniper	9%	2%	Low Sheep Use
15	Juniper	8%	0%	Low Sheep Use
16	Riparian	12%		Moderate Sheep Use
17	Sagebrush-greasewood	3%	11%	Low Sheep Use
18	Juniper	6%		Low Sheep Use
19	Juniper	4%	1%	Low Sheep Use
20	Sagebrush-greasewood	14%	50%	Heavy Sheep Use
21	Juniper	6%	15%	Moderate Sheep Use
22	Sagebrush-greasewood	5%	12%	Moderate Sheep Use
23	Sagebrush-greasewood	34%	50%	Heavy Sheep Use

Table IV-47 -- Cole Transect Data (Cont.)

Site	Vegetative Type	Use; <i>Artemisia</i>	<i>Sarcobatus</i>	Remarks
24	Juniper	8%		Low Sheep Use
25	Riparian	16%	31%	Heavy Sheep Use
26	Riparian	3%	2%	Low Sheep Use
27	Sagebrush-greasewood	2%	44%	Heavy Sheep Use
28	Riparian	25%	38%	Heavy Sheep Use
29	Shadscale	31%	20%	Heavy Sheep Use
30	Sagebrush-greasewood	40%	51%	Heavy Sheep Use
31	Sagebrush-greasewood	38%	25%	Heavy Sheep Use
32	Riparian	7%	24%	Moderate Sheep Use

TABLE IV-48

AVERAGE UTILIZATION BY VEGETATIVE TYPE

<u>Vegetative Type</u>	<u><i>Artemisia</i></u>	<u><i>Sarcobatus</i></u>
Riparian	12% (8)	24% (7)
Juniper	11% (8)	4% (4)
Shadscale	11% (8)	23% (3)
Sagebrush-greasewood	21% (8)	34% (8)

() - Number of transects completed

Weather conditions influence fawn production and survival in the intermountain area. Warm, wet springs are conducive to good fawn survival, and good forb production is essential for lactating does; cold, snowy springs decrease the chances of fawn survival. Dry conditions limit forb and grass production, and may restrict the nutrition of lactating does.

Weather conditions during the two years of the study were very different. In 1975 a wet spring induced good production of succulents. In 1976 a drought was beginning, and production was limited; however, the drop in fawn production in 1976 (from 81% to 72%) is not thought to be related to the drought. Although there were fewer fawns in 1976, there were more deer. Biologists working in the area felt that the incidence of twin fawns was high in 1975, and although more deer were present in 1976, many were unproductive yearlings. The White River herd is felt to be increasing; as it approaches carrying capacity, fawn production should stabilize at reduced levels from those of 1975 and 1976, with only normal, weather-induced variations.

Telemetry: The data from the telemetry and ancillary studies indicated that during both years weather conditions were atypical, and consequently the conclusions reached may not be true of other years. In both years deer use on the tracts was very low during the cold winter months. Telemetry sightings in January and February were almost non-existent. In February 1975, the aerial survey revealed only 20 deer on the entire project area. The next survey, conducted in December 1975, showed deer actively moving into higher elevations of the tracts. During January and February 1976, no radio sightings were made, although deer were observed in the higher areas adjacent to the tracts.

By March many deer returned to the riparian area along the White River, indicating a tendency to return to areas used the previous year. Two does were seen to return in 1976 to identical areas used during summer and fall of 1975. There are no data to indicate if this is also true for male deer, but it is probable that they do not have preferred areas: the two males located in 1975 and the males monitored during 1976 seemed to wander over larger areas and to spend more time in the more rugged upland areas away from the river. The males do not have the metabolic demands of pregnancy and fawn raising and seem to be more independent of the riparian area.

The sightings made during the summers of 1975 and 1976 show that does depend largely on the riparian habitat during this period. In most cases, they moved only a few hundred meters in the interval between sightings.

From the information available on deer movements and seasons of use, it is apparent that the limiting factor in the White River deer herd lies in the availability of summer range, which is entirely within the limited confines of the White River corridor.

The surrounding region, because of a lack of water and nutritious forage, is unsuitable habitat for successful fawning. Winter range, on the other hand, is extensive in this area. All the higher-elevation areas (above 1678 m [5500 ft]) are suitable for wintering deer during most years. There may be some competition with sheep for winter range in some areas, but much of it is available to wintering deer. This situation is the reverse of most deer herds in Utah, where winter range is the limiting factor in controlling population numbers.

The aerial trend counts in 1975 indicated that the mule deer population on the tracts is increasing. The information from this count will serve as a baseline from which subsequent changes in the population can be assessed.

Trend counts are considered inadequate for taking exact census counts, but under the right field conditions they can be good indications of population numbers. In the 1975 count, it was felt that with the substantial helicopter time available and the excellent counting conditions, a very close approximation of actual numbers was obtained. It is important, however, that no definitive conclusions on deer numbers be drawn from these data until many years of data, including that from pellet group and browse transects, be evaluated.

Hunting Pressure: Most of the deer kills were in early fall in areas of known deer concentrations--Hells Hole Canyon, White River riparian area from Hells Hole to Asphalt Wash, and Evacuation Creek. Only a few deer were taken outside these areas.

Variations in weather conditions and other parameters between years make it difficult to determine any trend in harvests on the tracts. Field observations indicate that deer numbers are increasing and that the harvest should also increase, but more years of data would be necessary before any definite trends could be established.

Pellet Group Transects: It should be noted that several sources of error are inherent in analyzing data from pellet group transects. Pellet groups can be missed, especially in riparian areas, where a rank growth of cheat grass (*Bromus tectorum*) creates a dense, concealing mat. Also, it is difficult to distinguish sheep pellets from deer pellets. Although many groups in the study were readily distinguishable as either deer or sheep pellets, some pellets could not be classified. For this study, all groups were classified as either sheep or deer pellets, based on subjective observation of known concentrations of sheep and deer using the area. Some error exists in this overlapping of pellet morphology. In the more xeric areas of the tracts pellet groups on unprotected ground are often washed away by the heavy, intermittent rains characteristic of the area, so that the integrity of the group is lost. In such cases, again, a subjective observer estimated what had been there. The age of pellet groups are also difficult

to estimate. In standard transect methods, the pellet groups of the previous year are counted. This is usually made easier because of the migratory patterns of deer, which have distinct winter and summer ranges, creating a definite age gap in pellet groups in either area. However, on the tracts, some deer use is evident in all vegetation types practically throughout the year, creating a gradient of pellet group ages. For this study, groups that appeared to be from the previous winter (1975-76) were counted in juniper, and from the immediately preceding year (1976) in the riparian areas. Deer use in the other two vegetative types was so low as to be indeterminate in assessing use per acre.

Riparian areas were the most heavily used on the tracts, followed closely by juniper. This correlates with previous field observations, which indicated that deer selectively use riparian areas in summer and upland juniper areas in winter. The other two types, shadscale and sagebrush-greasewood, indicated very low levels of use by deer, but moderate to heavy use by sheep.

The pellet group data collected in the four vegetation types indicated several major areas of deer use. One extends along the entire length of the White River riparian habitat. Another roughly corresponds with Tract U-b. Its limits are the eastern drainage divide of Southam Canyon, the southern border of Tract U-b to Evacuation Wash, then north along the Evacuation Creek drainage to the White River and west along the river to Southam drainage. A third is the upland juniper habitat north of the White River from Cowboy Canyon to the mouth of Asphalt Wash. An additional concentration of deer is found in the Hells Hole Canyon drainage during winter. Many of these deer move off the tracts in the winter after spending the summer and fall along the White River.

No conclusive reason has been found for the scarcity of deer in the western portion of the tracts. The Asphalt and Southam Canyon drainages are among the most heavily grazed areas on the tracts during winter sheep grazing, and therefore interspecific competition between deer and sheep may exclude many deer from using this area.

Pellet group data collected on the project area was statistically analyzed to determine areas of preferred use by deer. As described in the analysis of browse transect data, it was found that Tract U-a (Asphalt Wash and Southam Canyon) was the most heavily used by livestock. Conversely, it was found that at the 95% confidence level, deer use was lowest on Tract U-a. This further validated the field observations that sheep and deer use different areas.

The total deer population on the tracts was estimated from the pellet group data listed on Table IV-49. Utilizing the total

TABLE IV-49

PROJECT AREA DEER USE FROM PELLET GROUP DATA

Vegetation Type	Percent of Tracts*	DDU/Acre	Acres on Tract*	Deer Days Use
Juniper	39	2.1	10,140	21,294
Shadscale	39	0.5	10,140	5,070
Sagebrush-Greasewood	25	0	6,500	-
Riparian	7	3.7	1,820	6,734
Total				33,098

* Includes Tracts U-a and U-b plus 1.6-km (1-mi) perimeter of tracts

deer use on the project areas as determined by pellet groups, then,

$$\frac{33,098 \text{ Deer Days}}{365 \text{ Days}} = 90 \text{ Deer}$$

Field observations indicate that several conditions must be considered in using this figure:

There are errors in reading transects

Portions of the tracts (e.g., buttes and monoliths) are unavailable to deer

During mid-winter, many deer leave the project area

The first two conditions probably do not greatly influence population estimates. The last, however, could be an important factor. During some winters, much of the area may be unused by deer. During February 1975 helicopter flights only 17 deer were seen on the tracts. In January and February 1976 many deer were seen to leave the area. This reduced time of use, then, reduces the accuracy of the estimate, since it is based on year-round use. The actual number of deer initially present would be greater than the estimate derived from pellet group transects, dependent upon the amount of time and the number of deer which leave the area.

Browse Use Transects: The browse use data collected during the study and field observations of deer and livestock habits on the tracts indicate the importance of the different vegetative types to these animals. The heaviest pressure on vegetation is exerted by winter sheep grazing and summer and fall cattle grazing. The transects showed that sheep dominate browse use, and therefore sheep use was analyzed at each site, including analysis of the extent of sheep trailing and the density of droppings and field observations during the grazing period in areas of use.

The data indicates the percentage of new growth of sagebrush and greasewood that was browsed during the fall, winter, and spring of 1975-1976. The winter of 1975-1976 was as nearly average in snowfall and temperatures. The 1975 growing season in the area, however, was abnormal in that rainfall distribution and intensity favored greater browse production. Consequently, the study encompassed a period of abnormally high availability of forage. The percentages of use found would then be biased toward a lower figure than would be indicated for a normal year, when production is lower.

The sagebrush-greasewood vegetation type is characteristic of the bottoms of the larger drainages of the project area. Good examples are found in Southam and Asphalt canyons. Soils are deeper than in the higher, steeper upland areas, and forage production is better.

The highest percentage of browse use was in this vegetative type. Of eight transects, one exhibited low sheep use, one moderate sheep use, and six were heavily used. Use of sagebrush was as high as 40%, and of greasewood, as high as 51%. This use can be attributed almost entirely to wintering sheep, since year-round deer use and fall-cover use are minor. Deer use in this type is low because of the lack of water during summer and early fall and because of the large sheep concentrations in winter.

Riparian habitat is along the White River and along Evacuation Creek. The soils are deep, soil moisture is relatively high, and forage production is much greater than in the other vegetation types.

Utilization of the two browse species in this type was approximately 10% lower in each case than in the greasewood type. The riparian areas are probably much more important as a source of forage for livestock and wildlife than is indicated by the browse use percentages. The riparian areas are used almost year-round by herbivores. Deer are nearly restricted to this type during spring, summer, and fall, and fawning takes place almost exclusively along the White River, since it is the only place with the necessary succulent vegetation, water, and escape cover.

Pellet group counts revealed a level of 3.7 deer days use per acre on the riparian type. This was the highest seen in the project area. From June through October, cattle graze the White River bottoms extensively, using the grasses and forbs and later in the season browsing on sage, greasewood, rabbitbrush, and shadscale. Although in mid winter sheep graze most extensively in the higher elevations of the tracts, they do use the riparian areas to some extent. In March and April, when snow for water is not available, sheep graze along the White River.

The total forage production and consumption on the riparian type probably greatly exceeds that of any other type. When the use of cottonwood and other large vegetative types by beaver is considered, the disparity becomes even greater.

The shadscale vegetation type in the project area is characteristic of more xeric, exposed areas on the tracts. It is common on the upland bench land and on the drier hillsides. Soils are relatively shallower and drier than in the previous two vegetation types. Browse species here are sagebrush, shadscale, greasewood, and horsebrush, with very few grasses and forbs.

The percentage of use in this type is comparable to that of the riparian and about 10% less than that of sagebrush-greasewood.

Total production is considerably less than that of the riparian and less than that of the sagebrush-greasewood.

Browse use is almost exclusively by sheep in winter, when snow is available for water. In late summer and early fall, some cattle graze the area when the grasses and forbs in the riparian area dry up or are consumed and cows wander onto the adjacent benches to graze on shadscale, sage, and greasewood. Deer use in this type is very low. Pellet group counts indicated a level of 0.5 deer days use per acre, which is the second lowest found on the tracts.

The juniper vegetation type is characteristic of the rocky, xeric, higher elevations in the project area. Soils are shallow and often very rocky with very little undergrowth of shrubs, grasses, or forbs.

Browse use in this type is the lowest on the tracts. This was the only type where sagebrush was used more than greasewood. Productivity of browse and grass and forb species is very low. Black sage (*Artemisia nova*) is often found here instead of the larger big sage (*A. tridentata*).

Sheep use in this type was very low, except for a very few isolated areas; except for trailing, sheep use lower elevation areas for browsing. Cattle use in this type is almost non-existent and could be considered accidental. Deer use is second only to the riparian area in intensity. Pellet group counts revealed a level of 2.1 deer days use per acre. In light of field observations of deer wintering extensively in this type, the use of sagebrush here can be attributed almost entirely to winter deer use. This area is the only suitable deer wintering area on the tracts, because of higher elevations, where the deer can escape cold air inversions on the White River and because of the protective cover provided by the rocky, juniper-clad draws and hillsides.

Browse transect data were analyzed to delineate areas of selective use of the tracts by livestock and deer. Field observations had revealed that Tract U-a seemed to have the most sheep use, almost entirely in the Southam and Asphalt drainages; therefore, all browse transect data and pellet group data in Tract U-a, including those in Asphalt Wash, were analyzed and the same data for the rest of the tracts was treated similarly. The two populations were then compared statistically at the 95% confidence level for the following parameters: level of use of greasewood (*Sarcobatus*), level of use of sagebrush (*Artemisia*), and deer days use per acre.

It was found that greasewood use in Tract U-a was significantly greater than in the rest of the tract. Use of this species was highly characteristic of winter sheep browsing. Use of sagebrush was comparable between the two areas. Sagebrush was used by both

sheep and deer as a forage species. Analysis of pellet group data showed that deer use in Tract U-a was significantly less than in the rest of the tracts. These analyses indicate that the area roughly outlined by the boundaries of Tract U-a is primarily used by livestock, with very little deer use. The rest of the tract is used less heavily by livestock and significantly more by deer.

Evaluation of Baseline Program

In general, the data collected during the two-year baseline study provided useful information on the habits and activities of the White River mule deer herd, particularly when compared with the regional data collected for deer herd Unit 28A. The results of data collected show that there are significant differences between the tracts and Unit 28A.

The productivity data is a valuable tool in monitoring the condition of a deer herd. When supplemented with field observations, much relevant data can be obtained. It would seem that in a continuation of classification studies, a sample of 200 deer would be vital in monitoring the White River deer herd before, during, and after oil shale development.

The telemetry studies provided considerable data concerning the dynamics of the White River mule deer herd, including areas of preferred habitat, seasons of use, some migration patterns, and especially the dependence of doe deer on the riparian habitat. There were some drawbacks in the telemetry studies. A major factor was the disruption of radio signals in the rocky areas of the region, which limited the range of the signals. When a radio-collared deer was in a canyon, many times it was impossible to ascertain if it had left the area entirely or was merely in a location limiting transmission. It was also felt that during periods of extremely cold weather, the strength of the radio batteries was reduced, which would explain the lack of success during January and February 1976.

Under suitable field conditions, trend counts are valuable in monitoring populations. The count in 1975-1976 was conducted under excellent conditions and provided valuable information. The 1976-1977 count was not conducted because snow cover was always inadequate. Trend count data must be analyzed over a number of years and in conjunction with auxiliary studies (e.g., pellet counts and browse data) to arrive at a definite conclusion concerning deer numbers.

Harvest information provided a valuable additional method of monitoring conditions. The deer harvest study for the project area was simple, successful, and easily repeatable.

When analyzed in the light of extensive field observations, and considering the inherent sources of error, the pellet group data were valuable in monitoring deer use on the tracts. This study indicated the deer preferences in vegetation types and geographic areas. Changes in actual deer numbers and distributions, however, will become evident only after years of data collection because of changes in weather conditions, livestock distribution and numbers, and other year-to-year variables.

The browse use studies were useful in determining the influence of different vegetation types, particularly when compared with the pellet group and telemetry studies. Seasonal variation were determined as well as the effects of winter sheep browsing and summer and fall cattle grazing on deer activities.

b. Predators

Methodology

A telemetry study of coyotes and bobcats was initially proposed for the project to determine movements, areas of use, and seasons of use. A trapline of ten traps was maintained from September through November 1975 in an attempt to collar these predators, but the program was discontinued because of low populations of these species and the expected difficulty of monitoring them in the rough terrain. For the rest of the study coyotes were monitored using scent-post transects and scat analyses. Other predators, such as bobcats and mountain lions, were studied using opportunistic field observations.

The scent-post transect used was one of the routes the United States Fish and Wildlife Service has maintained since 1972 to monitor coyote populations in the western states. It was decided that the data from the route, which is along Highway 45 north of Bonanza, Utah, would be indicative of coyote populations in the project area. The methodology is described by Roughton (1974) and by Linhart and Knowlton (1973).

During summer and fall 1976 coyote scats were collected on the tracts to monitor the prey species being consumed. Scats were picked up opportunistically when found along roadways or in the field. Analyses for percentage by weight of hair type present was conducted in the DWR technical laboratory in Salt Lake City.

Summary of Results

Predator sightings on the tracts have been rare. In fall 1975 a young bobcat kitten less than a month old was seen at the

Evacuation Creek bridge. The animal was emaciated and had probably been abandoned. A mature bobcat was sighted on November 20, 1975, at Asphalt Wash, and a badger was sighted in September 1975 near exploration drill hole X-9. In 1976 the only indication of bobcats on the tracts was a single, fresh track along Evacuation Creek. Mountain lions are common in the East Tavaputs area, but only one was seen on the tracts during the study.

The data from coyote scent stations from the Bonanza route and from all other Utah routes are included on Table IV-50. The data from the Bonanza route show marked fluctuations in densities through the years of available data. The statewide data, however, show a gradual decrease from 1972 through 1975, with 1976 data at a level comparable to that of 1975.

The percent compositions by weight of hair in the 24 scats collected are listed on Table IV-51. As seen in the data, 16 of the 24 scats were composed almost entirely of rabbit hair and seven were largely or entirely deer hair. One scat was entirely cow hair. Five scats contained traces of insect parts. No evidence of sheep predation was obtained.

Interpretation and Conclusions

The wide population fluctuations shown in the data from the Bonanza area give no indication of any trends in population levels of coyotes. The field observations of DWR personnel and professional trappers in the area indicate that coyote populations were at a very low level in 1975, with a definite increase in 1976. The scent line data, however, indicate the reverse. Data indicate a definite decrease in coyote population levels statewide from 1972 through 1975. This discrepancy is probably related to the small sample size of a single transect with a 24-km (15-mi) route and only 50 stations as compared with the statewide index which includes 16 routes.

In comparing Bonanza route data with statewide data it is apparent that coyote populations in the Bonanza area are probably lower than in the state as a whole. The actual magnitude of the difference would be impossible to determine with the data available. A comparison of data indicates that coyote indices are generally much lower in Utah than in other inter-mountain states and are probably at a low level for Utah, as seen on Table IV-52.

Data on rodent, lagomorph (rabbits), and mule deer populations on the tracts and in the Book Cliffs area offer some insights concerning the present coyote populations. As described in the discussion of scat analysis, the rodent and lagomorph population in the area was probably at a low in 1974, as was the

TABLE IV-50

COYOTE POPULATION INDICES FROM SCENT-POST TRANSECTS

<u>Year</u>	<u>Bonanza (Route #5) Index</u>	<u>Statewide Index</u>
1972	No data	89
1973	32	50
1974	7	35
1975	26	23
1976	7	29

From Roughton 1977 (pers. comm.)

TABLE IV-51
COYOTE SCAT ANALYSIS

Percent by Weight of Hair in Coyote Scats				
Sample	Deer	Rabbit (Sylvilagus)	Cow	Rodent
1	100			
2	100			
3	100			
4	100			
5	100			
6		100		
7		100		
8		100		
9		100		
10		100		
11		100		
12		100		
13		100		
14		100		
15		100		
16		100		
17		100		
18		100		
19		100		
20			100	
21	90		2	8
22	80		20	
23	5	75	20	
24		80		20

TABLE IV-52
INTERMOUNTAIN AREA COYOTE INDICES

State	1972	1973	1974	1975
Utah	89	50	35	23
Arizona	151	142	176	183
Nevada	95	91	90	80
Idaho	87	65	86	85
Montana	62	71	78	74
Wyoming	52	62	63	72
Colorado	108	130	98	75
New Mexico	79	122	147	138

SOURCE: Roughton 1977

deer population of Unit 28A; therefore the food base of coyotes at this time was probably abnormally low. That same year two professional trappers, summertime denning by sheepherder employees, and aerial gunning by the U.S. Fish and Wildlife Service seriously depleted coyote populations. The cumulative effect of the low food base and heavy mortality resulted in abnormally low population levels during this period.

Scat analysis revealed that the predominant prey species of coyotes during the study period was cottontail rabbits. This was expected with the large, rapidly increasing rabbit population on the tracts. Rabbits furnished a readily available base with no danger of injury to the coyote, as might be the case with larger prey species such as deer.

Deer were the second most frequent species found in the scats. Neither the age of the hair samples (i.e., fawn or adult) nor whether the deer was killed or eaten as carrion could be determined.

One scat consisted entirely of cow hair. The cow was probably eaten opportunistically as carrion. Three additional scats contained less cow hair.

Rodent hair was found in only two scats, and then only in small amounts. With the high rodent populations at that time, there should have been more. The abundance of the larger cottontails may have been the reason there was not more rodent predation.

Sheep wool was expected to be found in the scat analyses, since according to Davenport et al. (1973), coyotes may consume as much as 4% of the approximately 10% of sheep lost every year (Wagner 1972). Sheep wool was not found in any of the samples, even when stray sheep were present in several areas of the tracts in summer 1976.

Evaluation of Baseline Program

Predator populations in the study area are low. This made it difficult to apply monitoring techniques to provide statistically reliable data. The telemetry program was initiated to monitor coyotes, bobcats, mountain lions, and other predators, but was abandoned after fall 1975 as completely unsuccessful. The scent-post transects and scat analyses were more successful, but only in monitoring coyotes. The occasional sightings of other predators did not yield enough data to assess their activities on the tracts.

It is felt that telemetry studies in this area, even with an adequate number of collared animals available, would have limited results. Most of the area frequented by predators is extremely

broken and rocky, where radio reception is very limited, and the effort required to adequately assess radio data in such a situation would probably be excessive for the benefits derived.

The scat analyses were a good indication of coyote activities, especially by mid-summer of 1976, when coyotes were apparently increasing and scats became common enough to collect. It is recommended that in future studies a larger sample size of scats should be analyzed. This should be no problem if the population remains at the present level or increases. Also, scat analyses should be conducted through the peaks and lows of rabbit-rodent populations to demonstrate any shift in diet during these periods.

Scent stations are probably the best method of assessing coyote populations, especially since it is standardized and can be used to compare data from a large area of the west. The data from only one station probably has low statistical reliability and therefore in future studies, it is strongly recommended that multiple transects, even shorter ones, be established, with frequent repetition of trap-night surveys. This should provide sufficient data to determine population trends. The scent-post transects and scat analyses were useful as indicators of predator activities on the tracts, but not of actual numbers. It is felt that determining populations, even on such a limited area, would be beyond the scope of even the most intensive studies with the methodologies available at this time.

c. Amphibians and Reptiles

Methodology

The amphibian and reptile study was conducted to determine the species inhabiting the project area, the relative abundance and distribution of each species in each of the four major vegetation types, and the relationships between reptiles and vegetation, lizards and snakes, and snakes and rodents. In addition, the study was conducted to integrate these findings with the general sampling data and pertinent literature (refer to Section IV.B.1 for additional information).

Two changes were made in the methodology of the lizard-grid mark-recapture study as outlined in the First Year Environmental Baseline Report (FYEBR). The first change involved resizing each grid from its 1975 area (ranged from 1.1 to 2.6 ha) to 1.0 ha (100m x 100m), which permitted direct comparison of the lizard fauna of each vegetation type. Reducing the size of the shade-scale grid made it more uniform by eliminating some ecotonal sagebrush-greasewood, and tamarisk had to be included in the 1.0-ha

grid. The uniformity of the sagebrush-greasewood grid and the juniper grid was not affected by resizing.

The second change in methodology was the use of red nail polish to mark lizards in 1976. In 1975 lizards were toe-clipped, which necessitated capturing all individuals every day to check for recaptures. The use of red nail polish required capturing an individual only one time. One disadvantage of using red nail polish was possible increased predation from avian lizard predators, which have color vision. It is not known if these predators perceive the color red as distinctly as do humans (Marler and Hamilton 1966); therefore, the net effect of color marking lizards is unknown. Another disadvantage of using nail polish is that the mark is lost when the skin is shed. When the difficulty of capturing lizards was considered, the nail polish was clearly advantageous to toe clipping, and there is a precedent for its use (Tinkle 1967).

It was decided not to shoot lizards, because adequate live individuals had been captured and marked. This was not a methodology change, since either option was open to use in the revised biology resources program (FYEBR). It was felt that shooting any wildlife would defeat the philosophy of non-consumption (non-impact) established in the baseline program.

The sampling effort per hectare in 1976 was not significantly less than that per hectare in 1975 as measured by a paired t-test ($p < 0.05$; that is, the non-difference is expected to be less than 5 times out of 100 due to random chance alone). Also, it was shown in the FYEBR that observations were random, that is, there was no significant correlation between the duration of sampling and the number of observations.

The amphibian and snake studies were conducted in the same manner in 1975 and 1976.

Summary of Results

Amphibians: Amphibians on the tracts were found only in the riparian vegetation along the White River and were active from May through September. No amphibians were found at gas-well water ponds south of Tract U-a or in Asphalt Wash or Evacuation Creek during flow events. Since the landform of the tracts precluded extensive pool formation during summer thundershowers, the absence of amphibians outside the riparian community was not surprising.

Four amphibian species were observed along the White River in 1976. The leopard frog (*Rana pipiens*) was the most common species. During summer 1976 leopard frogs were observed in a single basin directly west of Ignacio Stage Stop near the Bonanza pump station.

In June the basin contained four adult leopard frogs, several thousand leopard frog tadpoles, several Great Basin spadefoot toads (*Scaphiopus intermontanus*), several Woodhouse's toads (*Bufo woodhousei*), a chorus frog (*Pseudacris triseriata*), and many aquatic invertebrates. By August the pool was dry, and only a few adult and many juvenile frogs were present. Spadefoot toad tadpoles were not present; it was assumed they had metamorphosed and left the area.

All species observed in 1976 had been observed in 1975 with the possible exception of the chorus frog. An unconfirmed observation of this species was made in 1975.

Lizards: The following observations were made after analysis of two years of data (shown on Figure IV-22 and Table IV-53):

(1) In 1976 the three lizard species found in all four vegetation communities were the northern side-blotched lizard (*Uta stansburiana stansburiana*), the northern plateau lizard (*Sceloporus undulatus elongatus*), and the western whiptail (*Cnemidophorus tigris*). In 1975 the only lizard found in all four vegetation communities was the northern side-blotched lizard.

(2) In 1976 the northern sagebrush lizard (*Sceloporus graciosus graciosus*) was the most abundant lizard on the plots. In 1975 the northern side-blotched lizard was the most abundant lizard on the plots.

(3) In 1975 and 1976 the most abundant lizard within a vegetation type was the northern sagebrush lizard in the shadscale community.

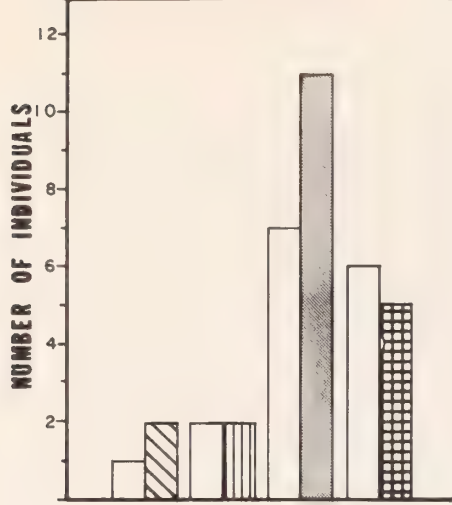
(4) In 1975 and 1976 northern plateau lizards and tree lizards (*Urosaurus ornatus*) inhabited standing and fallen cottonwood trees in the riparian community.

(5) In 1976 outside the riparian community the tree lizard was found only once in the juniper plot. In 1975 outside the riparian community the tree lizard was found only once in the shadscale plot.

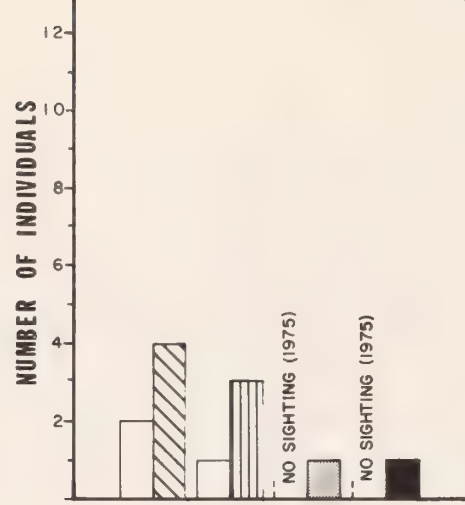
(6) In 1975 and 1976 the short-horned lizard (*Phrynosoma douglassi*) appeared to be restricted to the shadscale community.

(7) In 1975 and 1976 the western whiptail (*Cnemidophorus tigris*), the largest lizard in the area, was seen primarily in the sagebrush-greasewood community and to a lesser extent in the juniper and shadscale communities. The whiptails observed on the riparian plot were near or in greasewood.

(8) The total number of lizards by habitat for 1976 was not



RIPARIAN



SAGEBRUSH/GREASEWOOD

KEY

1975 1976



TREE LIZARD



SHORT-HORNED LIZARD



WESTERN WHIPTAIL LIZARD



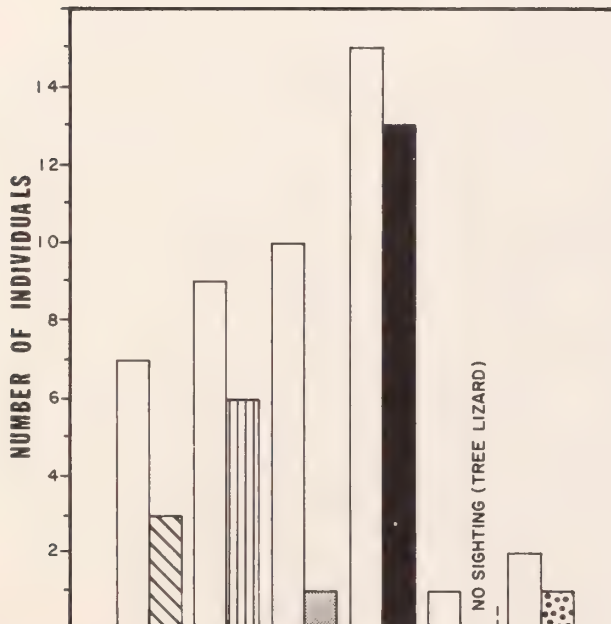
NORTHERN SIDE-BLOTCHED LIZARD



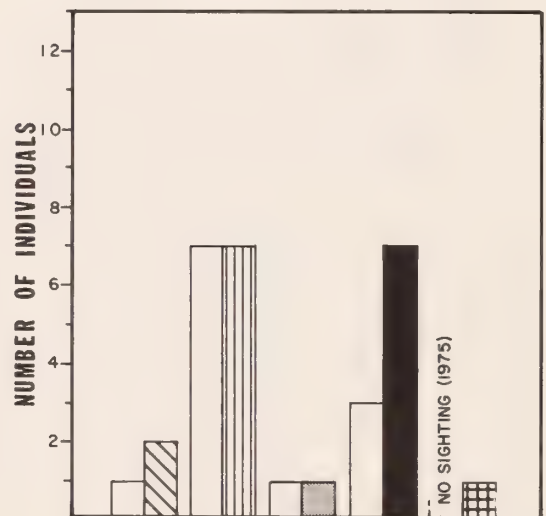
NORTHERN PLATEAU LIZARD



NORTHERN SAGEBRUSH LIZARD



SHADSCALE



JUNIPER

**NUMBER OF LIZARDS PER HECTARE
OBSERVED IN EACH VEGETATION TYPE**



TABLE IV-53
1975 - 1976 LIZARD COMPARISONS

	Significant Correlation Coefficients		Paired t-test
	p < 0.01	p	
Total Individuals by Habitat	0.85	<0.05	
Species Diversity by Habitat	- - -	<0.05	
Riparian Community Structure	0.88	<0.05	
Sagebrush-greasewood Community Structure	0.99	<0.005	
Shadscale Community Structure	0.83	<0.025	
Juniper Community Structure	0.85	<0.05	
Ecosystem Structure (all four communities)	0.95	<0.05	
Species Distribution by Habitat:			
Northern Palteau Lizard	- - -	<0.05	
Northern Sagebrush Lizard	0.94	<0.05	
Northern Side-blotched Lizard	0.89	<0.05	
Short-horned Lizard	1.00	<0.05	
Western Whiptail	- - -	<0.05	
Tree Lizard	0.95	<0.05	

- - - Correlation not significant

significantly different from 1975 (Table IV-53). Species diversity by habitat changed non-linearly, but not significantly so. Lizard community structure was not significantly different in 1975 and 1976. Lizard abundance changed in sagebrush-greasewood and shadscale, but overall lizard abundance did not change significantly. Species distribution by habitat changed for some species, but not significantly so.

(9) In 1976 the lizard community structures in each habitat were not significantly different as determined by "analysis of variance" (ANOVA). In 1975 the lizard community structure in each habitat was significantly different ($p < 0.01$), as determined by ANOVA.

(10) In 1976 application of the Shannon-Wiener Diversity Index to the lizard-marking program data indicated increasing species diversity in the order riparian (1.64), shadscale (1.74), sagebrush-greasewood (1.75), and juniper (1.88). In 1975 data indicated increasing species diversity in the order sagebrush-greasewood (0.92), juniper (1.55), riparian (1.68), and shadscale (2.23). Species diversity is a measure of the number of species and their relative abundance in different areas or habitats. There are no standards for this measure.

(11) The results of the lizard-population study for 1976 is shown on Table IV-54. In computing estimates, consideration was given to the decreasing number of marked animals observed through time as a result of shedding and differences in sampling times from month to month. In 1975 too few toe-clipped lizards were recaptured to make population estimates.

(12) In 1976 the number of lizard species was significantly negatively correlated with grass, forb, and total herbage production; that is, when grass production is high, the number of lizard species is low ($r = -0.86, -.93, \text{ and } -0.96$, respectively, where r is the correlation coefficient and $p < 0.01$ indicates the correlations are significant 99 times out of 100). Lizard species diversity was significantly negatively correlated with grass production ($r = 0.88, p < 0.01$) and total herbage production ($r = 0.87, p < 0.01$). In 1975 there were no such correlations. Limited sample size probably resulted in coincidental significant correlations without causality. If the correlations did express a causal relationship, it could have been that the lizards, most of which use a sit-and-wait approach for capturing prey, were avoiding grassy areas where visibility was reduced. It was assumed that the observer's visibility of lizards was not hampered by herbage cover.

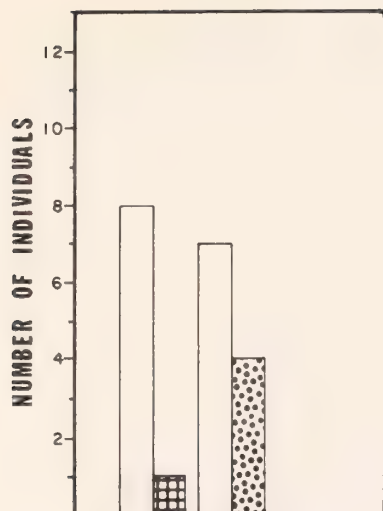
Snakes: The following observations were made from analysis of two years of data shown on figures IV-23 and IV-24 and tables IV-55 and IV-56.

(1) In 1976 the Great Basin gopher snake (*Pituophis melanoleucas deserticola*) and the desert striped whipsnake (*Masticophis*

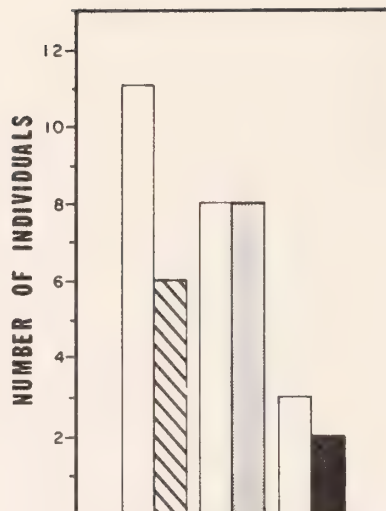
TABLE IV-54

1976 LIZARD POPULATIONS

Habitat/Species	Precensus Marked Lizards	Census Period June		Population Estimate	Census Period July		Population Estimate	Census Period August		Final Population Estimate
		Marked	Unmarked		Marked	Unmarked		Marked	Unmarked	
<u>Sage/Greasewood</u>										
Northern Side-Blotched	3	1	2	9	0	2	≥9	0	3	9
Northern Plateau	0	0	1	≥1	0	0	0	0	1	1
Western Whiptail	3	0	10	≥33	0	4	≥15	0	1	30-35
Northern Sagebrush	0	0	0	0	0	1	≥1			2-3
<u>Juniper</u>										
Northern Side-Blotched	14	3	12	70	0	6	≥98	0	14	70
Northern Plateau	1	0	2	≥3	0	3	≥4	0	2	3-5
Western Whiptail	1	0	5	≥6	0	2	≥3	0	4	6-8
Northern Sagebrush	7	2	5	24.5	2	8	35	0	4	25
Tree	0	0	1	≥1	0	0	0	0	0	1-3
<u>Shadscale</u>										
Northern Side-Blotched	6	7	6	11.1	0	5	≥6	0	5	11
Western Whiptail	3	0	7	≥24	0	1	≥6	0	0	20-30
Northern Sagebrush	13	9	24	47.7	5	22	70.2	0	12	50
Mountain Short-horned	1	0	0	≥1	0	0	0	0	0	1-3
Northern Plateau Lizard	0	0	0	0	0	0	0	0	1	1-3
<u>Riparian</u>										
Northern Side-Blotched	0	0	3	≥3	0	0	0	0	0	5-8
Northern Plateau	11	9	9	22	1	14	165	0	8	22
Western Whiptail	2	0	0	≥2	0	0	0	0	1	4-6
Tree	4	0	9	≥40	0	0	0	0	6	20-40



RIPARIAN



SAGEBRUSH/GREASEWOOD

KEY

1975 1976



WANDERING CARTER SNAKE



WESTERN YELLOW-BELLIED RACER



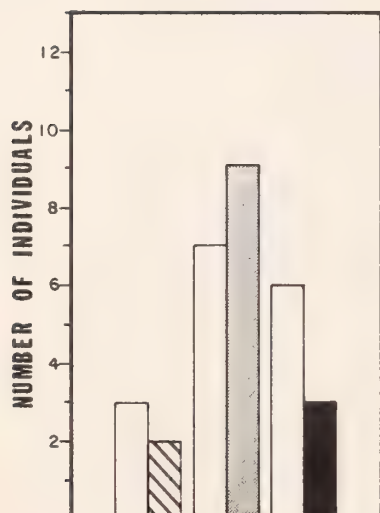
MIDGET FADED RATTLESNAKE



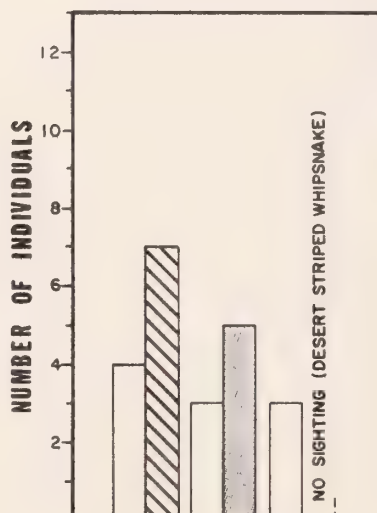
GREAT BASIN GOPHER SNAKE



DESERT STRIPED WHIPSNAKE



SHADSCALE



JUNIPER

**NUMBER OF SNAKES OBSERVED
IN EACH VEGETATION TYPE**



TABLE IV 55
1975 1976 SNAKE COMPARISONS

	Significant Correlation Coefficients	Paired t-test
	r	P
Total Individuals by Habitat	--	<0.05*
Species Diversity by Habitat	-	>0.05** <0.10
Riparian Community Structure	--	>0.05 <0.10
Sagebrush-Greasewood Community Structure	-	<0.05
Shadscale Community Structure	--	<0.05
Juniper Community Structure	--	<0.05
Ecosystem Structure (All Four Communities)	0.92	<0.05
Species Distribution by Habitat:		
Wandering Garter Snake	1.00	<0.05
Western Yellow-bellied Racer	1.00	<0.05
Desert Striped Whipsnake	0.83	>0.005
Great Basin Gopher Snake	0.88	<0.05
Midget Faded Rattlesnake	--	<0.05

-- Correlation not significant

* indicates the total number of snakes in each habitat in 1975 did not differ significantly from the total number of snakes in each habitat in 1976.

** indicates species diversity by habitat was significantly different for 1975 and 1976 at the 95% level of confidence but not at the 90% level of confidence.

TABLE IV-56
SIGNIFICANT CORRELATION COEFFICIENTS BETWEEN NUMBERS OF SNAKES
OBSERVED BY HABITAT AND NUMBERS OF ROBERTS MARKED BY HABITAT ($p < 0.01$)

	Western Harvest Mouse	Desert Woodrat	Bushytail Woodrat	Whitetail Antelope Squirrel	Golden-mantled Squirrel	Deer Mouse	Least Chipmunk	Apache Pocket Mouse	Ord Kangaroo Rat	Brush Mouse	Pinyon Mouse	Canyon Mouse
1955												
Wandering Garter Snake	..	..	1.00	..	..	..	..	..	..	..	..	..
Western Yellow-bellied Racer	..	..	1.00	..	..	..	..	..	..	..	..	..
Desert Striped Whipsnake	..	..	..	0.91	0.96	..	..	..	..	0.96	..	..
Great Basin Gopher Snake	..	..	..	0.84	..	0.91	..	..	0.93	..	..	..
Nidget Faded Rattlesnake	..	..	..	..	..	..	..	0.99	0.89	..	..	..
1956												
Wandering Garter Snake	..	..	..	..	..	..	..	..	..	..	..	..
Western Yellow-bellied Racer	..	..	..	..	..	..	..	..	..	..	..	..
Desert Striped Whipsnake	..	..	0.96	0.89	..	..	..	..	0.89	..	..	..
Great Basin Gopher Snake	..	..	0.91	0.91	..	..	..	..	0.87	..	..	..
Nidget Faded Rattlesnake	..	..	..	..	..	..	..	..	..	0.96	..	..

.. Correlation not significant

taeniatus taeniatus) were observed in all four vegetation types. In 1975 only the Great Basin gopher snake was observed in all four vegetation types.

(2) In 1975 and 1976 the Great Basin gopher snake was the most commonly observed snake on the project area.

(3) In 1976 the most commonly observed snake within a vegetation type was the midget faded rattlesnake (*Crotalus viridis color*) in sagebrush-greasewood. In 1975 the most commonly observed snake was the Great Basin gopher snake in shadscale.

(4) In 1975 and 1976 the wandering garter snake (*Thamnophis elegans vagrans*) and the western yellow-bellied racer (*Coluber constrictor mormon*) were observed only in the riparian vegetation type, while the midget faded rattlesnake was never seen in the riparian habitat.

(5) The total number of snakes by habitat changed from 1975 to 1976, but not significantly (Figure IV-24). Species diversity by habitat also changed significantly from 1975 to 1976. Snake community structure by habitat shifted from 1975 to 1976, but was not significantly different overall. Species distribution was quite similar except for the midget faded rattlesnake, which was seen more often in juniper in 1976 than in 1975.

(6) In 1975 and 1976 the snake community structures in each habitat were not significantly different, as determined by ANOVA.

(7) In 1976 the snake species distribution were significantly different, but not in 1975.

(8) In 1976 the number of snakes observed by vegetation type increased in the order riparian, juniper, shadscale, and sagebrush-greasewood. In 1975, the corresponding order was juniper, shadscale, riparian, and sagebrush-greasewood.

(9) In 1976 snake species diversity was lowest in juniper (0.98) and about equal in the other vegetation types (1.29 to 1.41). In 1975 species diversity was lowest in sagebrush-greasewood (1.42), about equal in shadscale and juniper (1.51 and 1.57), and highest in riparian (1.80).

(10) There were no significant trends in correlations among snake and vegetation parameters for 1975 and 1976 at the 0.01 (99%) level of significance. At the 0.05 (95%) level of significance, snake species diversity was significantly correlated with grass production and total herbage production. It was concluded that more years of data were necessary to establish whether the significant correlations expressed causality or random coincidence. A possible causal mechanism was that since grass and herbage production was an indirect measure of herbivorous rodent

production, it might have been that greater abundance of the prey resource permitted reduced competition.

(11) The only significant trends among snakes and lizards for the two years were significant correlations among the species generally restricted to the riparian habitat.

(12) Significant correlations between the number of snake species and pooled rodent data by habitat are shown on Table IV-56. All five species of snakes observed feed on small mammals (Stebbins 1966), so the correlations probably expressed causality, particularly that of the gopher snake with the Ord kangaroo rat and the desert striped whipsnake, and the western yellow-bellied racer with the whitetail antelope squirrel.

Amphibians: The amphibians appeared to be restricted to riparian areas along the White River. The only exception to this generalization might have been the Great Basin spadefoot toad, which is fossorial (above ground only when conditions are suitable, that is, after summer rains to breed, feed, and excrete) and therefore not restricted to areas near permanent water. During June 1975 sampling, spadefoots were chorusing and breeding in a stock pond 8 km (5 mi) north of Bonanza. Individuals were migrating to the pond at night and were observed crossing Highway 45, but no adults were heard or seen on the tracts. Tadpoles were seen in a temporary pond next to Ignacio Stage Stop when sampling began. In June 1976 several adults were seen in this pond, but tadpoles were not present. By July, the pond was drying up. It is not known if successful breeding occurred.

In general, the amphibians emerged from overwintering burrows in April, concentrated at ponds in May, bred in June, and retreated to burrows in September and October. Tadpoles were active in June and July, with metamorphosis to juveniles occurring during August. The amphibians were more active at night, particularly after rains, which increased their effective foraging range.

The limited number of amphibians observed during the baseline study probably implies a minor role in the ecology of the project area.

Lizards: The side-blotched lizard was the most abundant lizard on the habitat plots in 1975 and the second most abundant lizard in 1976. The northern sagebrush lizard was the second most abundant lizard on the habitat plots in 1975 and the most abundant lizard in 1976. These differences were not significant, and generally these two species occurred on the tracts in a 1:1 ratio. Tinkle (1967) reported that "...it is an exceptional situation where they occur together in nearly equal abundance." Tinkle (1967) also stated that no studies of habitat preference in side-blotched lizards (or any other) have been made. From

data collected on the tracts in 1975 and 1976 it appeared that both species preferred shadscale to the other three habitat types on the tracts (see Figure IV-22). The abundance in different habitat types was similar to that found in data collected by Parker and Pianka (1975).

Side-blotched lizards were first observed on the tracts in the juniper type on April 13, 1975, and on April 12, 1976. Emergence dates at equivalent latitudes and elevations could not be found in the literature.

Side-blotched lizards displayed a bimodal diel (two activity peaks during a 24-hour period) pattern of activity. They were active mornings and evenings and were usually inactive in shrub shade during midday. In early summer and early fall they were more unimodal, being active all day long.

Side-blotched lizards use the "sit-and-wait" diurnal foraging strategy, often perching on rocks for better vantage. When suitable prey is seen, the lizard stalks it and makes short dashes to capture it. Rummaging or climbing bushes are alternative strategies used less extensively. Their primary prey in the Great Basin Desert consisted of grasshoppers and crickets, beetles, ants, insect larvae, and spiders, all of which contributed about 75% of the total volume of the stomach contents of 556 individuals examined (Parker and Pianka 1975).

Known predators of side-blotched lizards include western whiptails, rattlesnakes, desert striped whipsnakes, and burrowing owls (Tinkle 1967). Potential predators include gopher snakes (Tinkle 1967), raptors, and shrikes.

Northern side-blotched lizards mated in mid-April at Colorado National Monument in Mesa County, Colorado (Tinkle 1967) and in May in north central Utah (Christiansen 1965). Hatchlings appeared in late July or early August. The average clutch size was 3.2 eggs in Colorado and 3.5 eggs in Utah. Theoretically, females could have three clutches per annum. At least 50% of the hatchlings required two years to reach maturity (Tinkle 1967). Tinkle (1967) also reported that turnover in resident adults was 60% to 70% per year.

Essghaier and Johnson (1975) noted a sight-census density of side-blotched lizards of 10 per ha in a shadscale-bud sage community in southern Idaho. Tract U-a and U-b density in shadscale was 6 per ha, with a population estimate of 11.1 per ha. Northern sagebrush lizards preyed on hymenoptera (primarily ants), hemiptera (true bugs), beetles, flies, moths, and spiders, in that order, according to two studies involving stomach contents of 1391 individuals (Knowlton 1934; 1942). In 71 northern sagebrush lizards (*S. graciosus*) collected near Salt Lake City, Pack (1921) found hymenoptera the most numerous, grasshoppers

next, and hemiptera third. Numerous beetles and spiders were also found. The stomach contents analyzed from 2191 northern sagebrush lizards over a 16-year period in Utah by Knowlton, Maddock, and Wood (1946) yielded almost 24,000 identifiable insects and other terrestrial arthropods. Again, hymenoptera were the most abundant, hemiptera second, beetles third, and moths fourth. In another study Knowlton (1953) found hymenoptera, beetles, moths, hemiptera, and spiders, in that order. Burkholder (1973) reported the number of insect species from stomachs of 210 individuals collected in 1971. The seven largest groups of prey, in descending order, were beetles, ants, grasshoppers, moths, spiders, flies, and true bugs. Potential predators included night snakes, yellow-bellied racers, desert striped whipsnakes, various raptors, ravens, coyotes, and longtail weasels (Burkholder 1973).

Burkholder (1973) found that sagebrush swifts mated in late May and early June. The average clutch size in that study was 6.03 eggs, which were laid in July. Incubation lasted from 6 to 7 weeks. Hatchlings appeared after adults had begun ingressing. Sexual maturity was reached from 22 to 23 months. The average population density of this species was about 66 per ha with a biomass of 408 g per ha. On the lizard plots on the tracts about 25 per ha were found in juniper and 50 per ha were found in shadscale.

The western whiptail was the largest lizard inhabiting the tracts, which lie in the northeastern part of this species' range. In northern parts of its range, western whiptails usually emerge from hibernation in May, and most adults aestivate during the midsummer months (Pianka 1970). Pianka's northern study sites were in the Great Basin Desert, western Nevada, and southwestern Idaho. The western whiptail on the tracts was observed on April 20 and 21, 1975, but not in April 1976. Adults of the species were observed in June, July, and August 1976, but analysis of variance indicated a significant reduction in numbers of individuals observed on each habitat plot from June through August. The conclusion is that while not all northern adult western whiptails aestivate, a substantial number probably do aestivate during the hottest months.

Whiptails displayed a bimodal diel pattern of daily activity, with more individuals active during morning than afternoon and retreating underground during the hottest part of the day. The timing of active periods followed shifts in the local temperature regime and changes in day lengths and climatic conditions.

Whiptails were observed to be aggressive diurnal foragers. They actively searched under shrubs, using their tongues to obtain olfactory cues for feeding. Some prey were captured in shrub interspaces. Their diet consisted of numerous invertebrates, primarily beetles and grasshoppers, but seasonal adjustments in

composition were made in response to prey availability (Pianka 1970).

Known predators include desert striped whipsnakes, western rattlesnakes, and gopher snakes (Pianka 1970). Raptors and shrikes must be considered potential predators (Pianka 1970).

Western whiptails engaged in mating activities during May and early June (Pianka 1970) and laid their eggs in late June (about June 21 in Mesa County, Colorado). The average clutch size was 3.4 eggs (Fitch 1970). Northern individuals probably required two years to reach maturity and usually survived three or four years (Pianka 1970).

Essghaier and Johnson (1975) noted a sight-census density of western whiptails (*Cnemidophorus*) of 8.5 per ha in a shadscale-bud sage community in southern Idaho. Tract density in shadscale was 10 per ha, with a population estimate of from 10 to 30 per ha. Minimal whiptail abundance figures obtained by Pianka (1970) for his northern Utah sites in 1964 during June, July, and August are significantly correlated with figures obtained for the tracts in 1976 ($r = 0.98$, $p < 0.01$) and not significantly different ($p < 0.05$).

Of the lizard species inhabiting the tracts, the short-horned lizard was the most restricted in terms of habitat utilization (shadscale only). Short-horned lizards apparently did not emerge from hibernation until May, although another species of horned lizard in northwest Utah has been observed emerging as early as March (Pianka and Parker 1975).

Short-horned lizards may display a bimodal activity pattern in June, July, and August and a unimodal activity pattern in May and September (Pianka and Parker 1975). This species has a longer daily activity period and is more eurythermal (tolerating a wide range of temperature) than are other lizard species on the tracts (Pianka and Parker 1975).

Short-horned lizards of the genus *Phrynosoma* used the "sit-and-wait" foraging strategy and have been observed often near ant colonies. *Phrynosoma* have specialized dentition that facilitates ant eating (myrmecophagy). Ants constituted 81% of prey items found in stomachs of 50 short-horned lizards (Pianka and Parker 1975). Beetles occasionally constitute a significant portion of the short-horned lizards (*Phrynosoma*) diet (Pianka and Parker 1975).

Pianka and Parker (1975) have postulated an explanation of *Phrynosoma* feeding ecology and its consequences on horned-lizard evolution. They argue that ants are small and contain much indigestible chitin, so that relatively large numbers of them must be consumed. Food specialization on ants is economically

feasible only because these insects occur in a clumped spatial distribution and thus constitute a concentrated food supply. These prey factors have had decided evolutionary consequences on *Phrynosoma*. To make efficient use of this spatially concentrated but not overly nutritious food supply, *Phrynosoma* has evolved a large stomach volume-to-weight ratio and an expanded time niche (that is, active for a longer time each day) relative to other lizard genera. These adaptations in turn have necessitated development of cryptic coloration and spines, offering some protection from predation, the probability of which has increased because the large stomach retards locomotion and the expanded time niche increases exposure. Another consequence of expanded activity periods is eurythermality (i.e., wide range of temperature tolerance) relative to other lizard genera. *Phrynosoma* are characterized by a unique spectrum of anatomical, behavioral, and physiological adaptations that facilitate efficient exploitation of ants as a food source and set the horned lizards apart from most other species of lizards.

Known predators include desert striped whipsnakes, rattlesnakes, raptors, and shrikes (Pianka and Parker 1975; Miller 1958).

Horned-lizards engaged in mating activities in late May and June (Pianka and Parker 1975). In Utah, short-horned lizards bore their young live (ovoviviparous) from mid-August to the end of August (Fitch 1970). Litter size varied from about 6 to 30 with an average size of about 10 (Fitch 1970). Pianka and Parker (1975) pointed out that large litters and a high rate of adult survival indicates high juvenile mortality. Individuals in Utah required two years to reach maturity (Pianka and Parker 1975).

Earliest observations of the northern plateau lizard (*Sceloporus undulatus elongatus*) on the tracts were in May 1975 and May 1976. Times of emergence from hibernation could not be found in the literature.

Like the other lizard species, northern plateau lizards inhabiting the tracts were diurnally active. The riparian assemblage displayed a bimodal activity pattern. More individuals were observed in the morning and late afternoon than at midday. This species was usually observed on cottonwood tree trunks, but it occasionally sat on boulders. Individuals on the ground retreated to cottonwoods when approached. The behavior of this species closely resembled that of tree lizards, who also inhabited the cottonwoods.

The prey of *Sceloporus undulatus* consisted primarily of grasshoppers, larval neuroptera (ant lions, dobson flies), homoptera (beet leafhoppers), true bugs, beetles, flies, moths, and spiders (Knowlton 1934). Potential predators included gopher snakes, rattlesnakes, night snakes, and several species of predatory birds (Tinkle 1972).

Northern plateau lizards on the tracts engaged in mating activities in May, and hatchlings appeared by July. Tinkle and Ballinger (1972) reported mid-July for hatchling appearance in Mesa County, Colorado, with presumed continued hatching into September. Clutch size averaged 11.8 hatchlings in Colorado from 1968 to 1971. Individuals required two years to reach maturity. Few adults lived to reproduce for more than three seasons. Tinkle (1972) found similar reproductive characteristics of a population in southwest Utah. He noted for the Utah population larger clutch sizes and three clutches per year versus two for the Colorado population.

Tinkle (1972) reported an average density of 35 *Sceloporus undulatus* per ha in riparian habitat comparable to that of the oil shale area. On the tracts the average population density of adults in June 1976 was 22 per ha in riparian habitat and 1 to 3 per ha in the other three habitat types.

The tree lizard has received the least attention by researchers of any lizard on the tracts. Previous studies of this species have concentrated on populations in Arizona, Texas, and Nevada (Asplund 1964; Asplund and Lowe 1964; Carpenter and Grubitz 1960 1961; Carpenter 1962; Milstead 1961, 1970; Worthington and Sabath 1966; Parker 1973; Martin 1973; and Vitt 1974). The information on these southern populations may not be pertinent to the population on the project site because of latitudinal changes in behavior, morphology, etc. (see particularly Pianka 1965, 1970; Pianka and Parker 1975; Tinkle and Ballinger 1972).

The tree lizard was first observed on the project area in May 1975 and then again in May 1976. The actual time of emergence from hibernation was unknown. This species was diurnally active and displayed a distinct bimodal activity pattern. Preference for morning hours (0900-1100) over early evening hours (1600-1900) was not evident. Observations for 1976 in riparian habitat consisted of 13, 0, and 6 observations in June, July, and August, respectively. These data indicated that the tree lizard may aestivate in July like the western whiptail.

The only information concerning prey items known for tree-lizard populations in Utah was reported by Knowlton (1934). He found primarily leaf hoppers, true bugs, larval beetles, flies, moths, ants, spiders, and mites in 45 stomachs of what was then called the Rocky Mountain tree Uta. That these two species belong to different genera is now commonly accepted. The predators of tree lizards were presumably the same as for northern plateau lizards, which coinhabited cottonwoods with tree lizards.

There is very little information concerning reproduction in Utah populations. In southern populations, females were gravid (i.e., carrying fertile eggs) from March through August in Arizona. Clutch size averaged 4.8, and one or two clutches

were produced annually. Hatchlings appeared from mid-June through November and reached sexual maturity in less than one year (Parker 1973).

The northern sagebrush lizard was first observed on the tracts on April 20, 1975 and on April 4, 1976. Burkholder (1973) reported that emergence started in early March from 1970 to 1972 in Utah County. This species was last observed on the tracts in October 1975 and October 13, 1976. Burkholder (1973) reported this species entering hibernation in late August and early September.

Burkholder (1973) found a trimodal diurnal activity pattern from March through June. First daily observations were around 0700 hours, with the most individuals active at about 1030 hours, 1300 hours, and 1700 hours, and the last observations were at about 1900 hours. Data for the tracts were very similar.

Snakes: The snakes on the tracts generally emerged from hibernation at the same time as the lizards. In 1976 the first snakes observed were a yellow-bellied racer and a gopher snake on April 23. Brown (1973) reported emergence of yellow-bellied racers between April 26 and May 5 from a hibernaculum in Tooele County, Utah. Parker (1974) reported emergence of gopher snakes between May 4 and May 20 and emergence of desert striped whipsnakes, between April 23 and May 20 from hibernacula in Tooele County, Utah.

Ingress (entrance into hibernation) of snakes on the tracts generally occurred at the same time as the lizards. In 1976 the last snakes observed were a yellow-bellied racer on October 6 and a gopher snake on October 16, both in shadscale above the riparian sampling area. Brown (1973) reported ingress of yellow-bellied racers occurred between September 13 and October 25 at the hibernaculum in Tooele County, Utah. Parker (1974) reported ingress of gopher snakes and desert striped whipsnakes between September 3 and October 25.

The snakes on the tracts were variable with respect to daily and seasonal activities. Desert striped whipsnakes were active throughout the day and all summer. Gopher snakes were seen mornings, afternoons, and occasionally on roads at night. Midget faded rattlesnakes were seen mornings and at night. Yellow-bellied racers and wandering garter snakes were active during the day and were not seen at night. The timing of the observations correlated with known activity periods of the species in Tooele County, Utah, studied by Parker (1974), Brown (1973), and King (1968). Basically, diurnal species basked in the morning and retreated to shrub shade or underground during midday, becoming active again in late afternoon. Nocturnal species such as rattlesnakes became active in early evening and retreated to shrubs or underground by the following mid-morning. In May,

males of each species were more often seen because they were seeking females with which to mate.

Specific information regarding prey and predators is given on Table IV-57. This table is not exhaustive; diet information derived from Brown (1973) and Parker (1974) includes only items constituting more than 10% of the total diet. In general, potential predators of garter snakes and rattlesnakes include raptors and carnivores, but no specific references were found.

Snakes engaged in mating activities on the tracts in April, May, and June. Parker (1974) reported that females of the Great Basin gopher snake (*Pituophis*) and desert striped whipsnake (*Masticophis*) deposited eggs ($X=7.44$ and 5.55 , respectively) between June 24 and July 2 and that eggs hatched in 45 to 60 days. Hatchlings appeared in late August and early September. Females of the western yellow-bellied racer (*Coluber*) deposited an average of 5.77 eggs per individual between June 27 and July 15 (Brown 1973). Eggs hatched 40 to 45 days later from mid-to-late August. Males of *Pituophis*, *Masticophis*, and *Coluber* became sexually mature at the ages of 1 to 2 years, 1 year, and 1 year, respectively. Females became sexually mature at the respective ages of 3 to 5 years, 3 years, and 3 years. Individual gopher snakes, desert striped whipsnakes, and yellow-bellied racers have been known to live more than 6 years, and there is a record of a 20-year-old gopher snake. Known population dynamics of snake species inhabiting the tracts are included on Table IV-58.

Amphibians apparently are not important in the ecology of the project area because so few have been seen during the baseline study. In contrast, reptiles appear to be an important segment of the vertebrate population. The abundance of lizards implies an important function in ecosystem energy transfer. The stability of lizard populations through two climatically different years gives support to their use as biological indicators because probably only development-related impacts would affect populations. The abundance of snakes, which usually occupy the top predator niche (tertiary consumer), probably reflects a high biological productivity for this area.

Table IV-59 lists the species represented in the U.S. National Museum collection and those observed during the baseline study on the project area.

Evaluation of Baseline Program

The opportunistic sampling in the amphibian and reptile program has fulfilled the lease stipulations, the conditions of approval, and the revised biology resources program. The information concerning inventory, habitat use, and relative abundance is adequate to determine project impacts.

TABLE IV-S7
TROPHIC RELATIONSHIPS OF SNAKES

	<u>Prey</u>	<u>Known Predators</u>	<u>Food Competitors</u>	<u>Sources of Information</u>
Wandering Garter Snake	slugs, leeches, earthworms, fish, frogs, salamanders, toads, lizards, tadpoles snakes, small mammals, occasionally birds	-----	-----	Stebbins (1966) Shaw & Campbell (1974)
Western Yellow-bellied Racer	grasshoppers, ground crickets, frogs, small mammals	Whipsnakes, burrowing owls, kestrels	Side-blotched lizards, Brown (1973) shrikes, kestrels, burrowing owls	
Desert Striped Whipsnake	Side-blotched lizards, <i>Perognathus</i> , <i>Peromyscus</i>	Whipsnakes, weasels, red-tailed hawks, racers, ravens	Gopher snakes	Parker (1974)
Great Basin Gopher Snake	<i>Peromyscus</i> <i>Perognathus</i>	red-tailed hawks, ferruginous hawks, Swainson's hawks, Great horned owls	Whipsnakes	Parker (1974)
Midget Faded Rattlesnake	small mammals, lizards, frogs, insects	-----	-----	Stebbins (1966) Shaw & Campbell (1974)

TABLE IV-58
POPULATION DYNAMICS

<u>Species</u>	<u>Density</u>		<u>Biomass</u> g/ha	<u>Home Range</u>	
	<u>No./ha</u>	<u>(No./acre)</u>		<u>ha</u>	<u>(Acres)</u>
Wandering Garter Snake	0.65	(0.26)	37	0.4	(1.0)
Desert Striped Whipsnake	0.11-0.33 (0.04-0.13)		14.3-39.9	7-35 (17.3-86.4)	
Great Basin Gopher Snake	0.32	(0.13)	65.4	~1-2 (2.5-4.9)	

Source: Parker (1974)
Brown (1973)

TABLE IV-59
AMPHIBIAN AND REPTILE SPECIES

Common Name ¹ Potential Species ¹	Scientific Name ¹	Uintah County Specimens in U.S. National Museum Collection ²	Observed During Baseline Study on Project Area ³
Tiger Salamander	<i>Ambystoma tigrinum</i>	●	
Western Chorus Frog	<i>Pseudacris triseriata</i> <i>triseriata</i>		●
Leopard Frog	<i>Rana pipiens</i>	●	●
Rocky Mountain Toad	<i>Bufo woodhousei</i> <i>woodhousei</i>	●	●
Great Basin Spadefoot	<i>Scaphiopus intermontanus</i>		●
Northern Plateau Lizard	<i>Sceloporus undulatus</i> <i>elongatus</i>	●	●
Northern Sagebrush Lizard	<i>Sceloporus graciosus</i> <i>graciosus</i>	●	●
Northern Side-Blotched Lizard	<i>Uta stansburiana</i> <i>stansburiana</i>	●	●
Short-horned Lizard	<i>Phrynosoma douglassi</i>	●	●
Western Whiptail Lizard	<i>Cnemidophorus tigris</i>	●	●
Tree Lizard	<i>Urosaurus ornatus</i>		●
Wandering Garter Snake	<i>Thamnophis elegans</i> <i>vagrans</i>	●	●
Western Yellow-bellied Racer	<i>Coluber constrictor</i> <i>mormon</i>	●	●
Great Basin Gopher Snake	<i>Pituophis melanoleucas</i> <i>deserticola</i>	●	●
Desert Striped Whipsnake	<i>Masticophis taeniatus</i> <i>taeniatus</i>		●
Midget Faded Rattlesnake	<i>Crotalus viridis</i> <i>concolor</i>		●
Milk Snake	<i>Lampropeltis triangulum</i> <i>taylori</i>		● ³
Mesa-Verde Night Snake	<i>Hypsiglena torquata</i> <i>loreala</i>		

¹Common names, scientific names, potential species list based on Stebbins, 1966.

²Confirmation of species occurrence in Uintah County from geographic card file of the National Museum of Natural History, Smithsonian Institution.

³Captured about 6.7 KM (4 miles) north of project area.

Density estimates are adequate for most lizard species, and population estimates are adequate for some species (those most abundant). The baseline would have to be continued for a number of more years to obtain reliable (statistically) conclusions, although lizards on the tracts are remarkably stable in terms of abundance and habitat use.

The meager amphibian fauna and the secretive habits of snakes preclude population estimates of these species using currently available field techniques. Densities and relative abundance by habitat of snakes and amphibians would be adequate to predict project impacts within an order of magnitude. This is acceptable considering that there is little knowledge of amphibian and reptile community structures and that biologists are presently unable to place economic values on these species the way they can on game species.

d. Waterfowl

Methodology

Canada geese and other waterfowl were studied during monthly float trips on the White River between March and September from stations S-1 (Hells Hole Canyon) to S-11 (west of Asphalt Wash) during the two-year baseline period. Waterfowl other than geese were observed and noted on a species list. All observations of geese were recorded, and when possible, age and pairing status were included. A spring census was conducted to count the number of birds and the number of unpaired (or flocked) and paired birds. A summer census was conducted to count the number of birds and the number of juvenile birds; successful breeding pairs; and unclassified birds (e.g., mixed juveniles, adults not distinguishable as broods).

Summary of Results

Canada geese are the most numerous waterfowl using the White River. Canada geese feed and nest along the White River within the project area from early spring through late summer. Other waterfowl species observed intermittently, and for which no estimates of populations could be obtained, include mallards, gadwalls, blue- and green-winged teals, avocets, willets, Wilson snipes, American mergansers, and great blue herons. No young of any of these species were observed. On October 13, 1975, approximately 300 sandhill cranes were observed flying south over the project area, and some of them landed on the tracts. At about the same time in 1976, sandhill cranes and one whooping crane migrated south over the tracts.

In July 1975, when nesting activities were completed, 43 Canada geese were observed, including 18 juveniles, 6 paired adults, 8 mixed young and old, and 10 unclassified and one unpaired adult. Nesting geese were observed using the numerous small islands, mud and sand bars, and debris piles of the White River. Nesting season varied, with the first brood observed May 6, and a brood of 6 small and flightless juveniles observed July 16. The average brood size was six juveniles per successful pair. By September 1975 all geese had left the river, and none were observed on subsequent surveys through November.

In 1976 float trips to count Canada geese were initiated soon after the break-up of river ice in March and continued through September. The maximum counts of adult geese were obtained during late March and mid April, when 35 and 37 geese, respectively, were observed. As of April 18, no goslings were present; however, from this date the number of adults decreased and goslings increased until a maximum total population was attained on June 9. At this time, 5 pairs of adult geese with 35 goslings, and 2 unpaired adult geese, were present. The average brood size at that time was 7 goslings. On subsequent surveys in late July, mid-August, and mid-September, no Canada geese were observed on the White River.

Interpretation and Conclusions

Canada geese and some waterfowl use the White River adjacent to the project area from the time ice breaks up, in early spring, until July, when goslings are mature enough to leave the area. Breeding adults, non-breeding adults, and immature birds are present during early spring. During the nesting season (late April through early June), non-breeding or unsuccessfully breeding birds leave the area presumably to complete molting elsewhere, since this period encompasses the molting season. During this time, successfully breeding birds are bringing off broods on the White River. When brooding is complete, the peak population for the year is reached. The two census counts indicated that this peak occurred in late June 1975 and in early June 1976. These times are imprecise, since the surveys were not conducted at the same time each year. The data does indicate, however, that the true population peak occurs during June, when during the surveys almost all non-breeding birds had left the area, leaving only goslings and breeders.

Maximum Canada geese populations were very similar in 1975 and 1976 (43 versus 47); however, there was a wide discrepancy in gosling production in 1975 and 1976 (18 versus 35). This was partially explained from observations made in 1976 (when all geese observed were classified). In 1976, at the peak of gosling production, almost all non-breeding geese had left the area.

At the same time in 1975, however, there were eight mixed young and old, ten unclassified, and one unpaired adult. The eight young and old were probably an early successful brood and parent adults. If the ten unclassified birds observed in 1975 were an early brood (based on 1976 observations), then in 1975 there would have been 32 goslings in 5 broods with one additional unpaired adult, in which case the data from 1975 and 1976 agree closely: maximum population (43 versus 47); total broods (5 versus 5); goslings per brood (6.4 versus 7.0); and remaining non-breeding birds (1 versus 2).

There would still be a slight discrepancy in the maximum number of adult birds present prior to the nesting season in 1975 and 1976 (28 versus 37). This may be the result of an increased population in the area in 1976. If such is the case, it is probable that many of the yearling geese (non-breeding as yearlings) hatched in 1975 returned in 1976 to inflate the pre-nesting population. Also, natural fluctuations in populations and migration patterns cause year-to-year differences.

No data were collected on the number of successful nests compared to attempted nesting on the White River. The brood counts, then, reflect the average size of successful broods, and not the number of goslings per breeding pair. Indications from project data are that production was very good in comparison with that of other areas of the state, as seen on Table IV-60. In both years, the average brood size was larger than that of the state as a whole and larger than that at the Brown's Park Waterfowl Management Area in Daggett County (Regenthal and Jensen 1976).

The White River ecosystem is important to Canada geese as a nesting and brood-rearing area. Numerous islands, mud and sandbars, and debris piles scoured by yearly spring flooding serve as ideal nesting sites. The riparian floodplain flanking the river provides feeding and escape habitat for both adult geese and goslings during summer. Rank growths of clover (*Melilotus*), forbs, and grasses provide grazing for adults and insects for young goslings. This vegetation and dense areas of phragmites and tamarisk furnish escape cover for goslings and for adults during the molting season.

Evidence collected in the study indicates that the river serves no function in the life cycle of Canada geese other than as a spring staging area and a nesting and brood-rearing habitat. Non-breeding and unsuccessfully breeding birds leave the river after spring and migrate elsewhere to molt. There are no data to indicate where this molting area is, although birds from the upper Green River in Brown's Park go to Ocean Lake in Wyoming (Folks 1976). Successful breeders use the river during nesting, brood rearing, and subsequent molting and then leave immediately afterwards. There is no indication that geese use the river during the fall for a resting area while migrating.

TABLE IV-60
AVERAGE NUMBER OF GOSLINGS PER BROOD

Year	Statewide ¹	Browns Park WMA ¹	Project Area
1975	4.65	2.9	6.0 ²
1976	4.68	4.75	7.0

1 Regenthal and Jensen 1976.

2 Based on minimum figure of 18 goslings.

Evaluation of Baseline Program

The data collected during the baseline study offer good evidence of a healthy, productive population of Canada geese on the White River in the project area. During the two years, the breeding population was stable or slightly increasing with good gosling production. It is felt that the status of Canada geese was accurately documented because of the narrowness of the river and the absence of alternative wetland areas on the tracts. As previously discussed, young-adult classifications from 1975 were incomplete, although total numbers were tallied. This was the result of the apparently large variation in hatching dates that year. In 1976, no such problem was encountered, and goslings were all of a relatively similar age.

Frequent surveys during one season could well be detrimental to broods of goslings scattered by the observer's canoe in the narrow river channel, which could result in an increased susceptibility to predation or physical injury. Therefore, it is recommended that in subsequent studies of Canada geese the present program be followed because it is felt to have been adequate for studying the geese while not disturbing them unduly. A single minor change would be to conduct two surveys in June, one during the first week and one during the last. This would insure a good maximum gosling count for the year.

e. Raptors

Methodology

Active eyries were located during helicopter flights in late May and early June for 1975 and 1976 and then monitored from the ground to determine reproductive success. A species list was compiled from observations made during the summer and winter aerial flights and opportunistic sightings throughout the two-year program.

Summary of Results

Data collected during the 1975 spring and winter raptor surveys are discussed in the FYEBR. During late May 1976, the spring raptor survey was completed on the project area. Two days were spent in an on-the-ground survey of all areas of the tracts to observe raptor activities and one day was spent floating the White River to observe raptor activities along the river. Records were kept of raptors observed, nesting activities and locations, and where possible, young produced in active nests.

Table IV-61 lists the raptors observed during the May 1975 and May 1976 surveys. Species observed included the golden eagle, red-tailed hawk, prairie falcon, kestrel, marsh hawk, Cooper's hawk, great horned owl, and turkey vulture.

Table IV-62 lists the locations of all active raptor nests observed during the survey. There were no nests on Tract U-a and only one on Tract U-b, located in the southwest portion of the tract. Species observed actively nesting were the golden eagle, Cooper's hawk, great horned owl, and red-tailed hawk.

The most common nester was the great horned owl, with five active nests. The lack of active nests sighted in 1975 was probably due to the observer's missing the nest locations and not to an absence of breeding birds. From observations of active nests in 1976, owl nesting habitat in the project area is quite common. Typical nest sites are in holes in south-facing flat-faced rock walls 3 m to 7 m from the ground. Two nests were in the riparian vegetation and three were in higher, upland shadscale vegetation. Since owl nest sites are often inconspicuous because of lack of white-washing or nesting materials frequently found at the nest sites of other raptors, it is felt that there are more owl nests in the area than were actually located.

Two Cooper's hawk nests were located during the survey, both in cottonwood trees in the riparian vegetation. One bird was observed in a nest that in 1975 was used by a long-eared owl that successfully brought off a brood of young. The other was a newly discovered nest near exploration drill hole X-2, which contained two downy young on June 9, 1976.

Two active golden eagle eyries were located in 1976, both off the tracts in high, inaccessible cliffs above the White River. One nest in Asphalt Wash was approximately 1.6 km from an eyrie that was active in 1975 but inactive in 1976. On June 3, 1976, it contained one partially fledged young bird. It is possible, considering the large territories established by breeding golden eagles, that these are the same birds that nested at the other site in 1975. It should be noted that the 1975 site was in a high ledge above, and directly visible from, the water station at S-11, a site of human activity. The 1976 site was on a ledge only visible from the river or from land after a hike of over two kilometers and a climb of 200 m (600 ft) over rough terrain. It is possible that the increased human activity caused this pair of golden eagles to relocate their nest site to a more inaccessible area.

The second golden eagle eyrie was located in the high cliffs north of the White River above the mouth of Hells Hole Canyon. This site contained two young birds in 1976. There are three alternative eyries on this same rock face, and it has obviously been a popular nesting site in the past.

TABLE IV-61
 SPRING RAPTOR SURVEY
 1975-1976

	<u>May 1975</u>	<u>May 1976</u>
Golden eagles	8	9
Prairie falcons	2	3
Red-tailed hawks	6	2
Cooper's hawks	2	1
Marsh hawk	0	1
Kestrels	9	9
Great horned owls	0	2
Turkey vultures	5	5
Long-eared owls	2	0
Bald eagles	3	0

TABLE IV-62

ACTIVE RAPTOR NEST SITES
1975 AND 19761975 NESTS

<u>Species</u>	<u>Location</u>	<u>Young</u>
Red tailed hawk	Gas well, Center Fork of Asphalt Wash, Sec. 8 (cliff)	2
Red tailed hawk	400 meters upriver from Ignacio (Tree)	2
Golden eagle	Cliffs across river from A-1 (west of U-a)	1
Prairie falcon	In nest at A-11 (southwest on Tract U-b)	4
Long eared owl	Mouth of Cowboy Canyon (cottonwood)	3

1976 NESTS

<u>Species</u>	<u>Location</u>	<u>Young</u>
Golden eagle	1.2 Km NE of F-5 (cliff)	1
Golden eagle	Cowboy Canyon (cliff)	2
Cooper's hawk	Mouth of Cowboy Canyon (cottonwood)	Unknown
Cooper's hawk	0.8 Km WSW of X-2 (cottonwood)	2
Great horned owl	0.4 Km NE of Ignacio Stage Stop (cliff)	3
Great horned owl	1.2 Km NE of A-3 (cliff)	2
Great horned owl	1.6 Km N. of S-4 (cliff)	3
Great horned owl	1.2 Km NW of S-13 (cliff)	2
Great horned owl	2.4 Km S of gas well in C. Fork Asphalt Wash (cliff)	3
Red-tailed hawk	1.6 Km S of gas well in C. Fork Asphalt Wash (cliff)	3
Red-tailed hawk	2.4 Km mile S of gas well in C. Fork Asphalt Wash (cliff)	2
Kestrel	Ignacio Stage Stop (cliff)	Unknown

One active red-tailed hawk nest was located in 1976 in Asphalt Wash. This nest is approximately 2 km from a nest site that was active in 1975 but inactive in 1976. This may be an alternate nest site for the same breeding pair. A red-tailed hawk nest near Ignacio Stage Stop that was active and successful in 1975 was unoccupied in 1976. A red-tailed hawk was observed in the cliffs above this site on June 11, 1976; however, no territorial behavior was displayed.

No active prairie falcon nests were located during this survey. A nest that was active and successful in 1975, near Station A-11, was inactive in 1976. On June 24, 1976, a prairie falcon was observed perching near the site, but no behavior indicating nesting activity could be observed. The cause for abandonment of this nest is unknown, since prairie falcons have strong tendencies to return to successful nest sites. The cause probably relates to its location, which is in a heavily traveled portion of the tract and is visible from two different roads. Additionally, core drilling by the lessee was taking place less than 1 km northwest of the site during the nesting season.

In January 1977 a winter raptor survey was conducted throughout the tracts. In most instances the number of birds and species was similar to that of the 1975 winter survey (Table IV-63). Exceptions were an increase in the number of rough-legged hawks observed in 1977 (from 1 to 6) and the presence of one red-tailed hawk in 1977, compared to none in 1975.

There were two major differences between the two years of the survey that affected raptor activities. In 1975 several heavy snowstorms occurred prior to the winter survey, and sub-zero temperatures were recorded. Only one light snowfall preceded the 1977 survey, and temperatures were moderate. Consequently, the timing and pattern of 1976-1977 winter migrations may have been delayed or altered. Another major difference between the two years was the significantly higher populations of rodents and rabbits in 1976 (USDI 1973). As a result of the increased food base, nesting success in the area probably increased and raptors tended to remain longer in the area or to migrate in and then remain there.

Interpretation and Conclusions

Studies by Olsen (1973) and Behle and Perry (1975) and studies conducted through the White River Shale Project provide a baseline of information on the relative abundances and seasons of use of the raptors using the project area. The following is a summary of information on each species observed during the study period.

TABLE IV-63
WINTER RAPTOR SURVEY
1975 AND 1976

	<u>December 1975</u>	<u>January 1977</u>
Mature golden eagles	9	7
Immature golden eagles	2	3
Mature bald eagles	2	1
Immature bald eagle	1	1
Prairie falcon	1	2
Rough-legged hawks	1	6
Red-tailed hawks	0	1
Marsh hawks	2	2

Golden Eagle (*Aquila chrysaetos*): The golden eagle is a common, year-round inhabitant of the project area. Eagles may be observed hunting along the cliffs near the White River, in the open sagebrush-shadscale desert, or in the higher juniper covered hills at any time of the year. Abundant rodent and rabbit populations provide a good prey base (USDI 1973). The high, sheer cliffs along the White River and in the larger upland drainages furnish nesting sites (Behle and Perry 1975).

Three active eyries were located on the project area, but off Tracts U-a and U-b, during 1975-76: one above Hells Hole Canyon and two near the mouth of Asphalt Wash, both on high, isolated cliffs overlooking the White River. Golden eagles have rather large nesting territories compared with those of some other raptors. Some observed territories in the intermountain area have been 38-60 sq mi/pair in western Utah (Murphy et al. 1969), 25.5-35.5 sq mi/pair in southwestern Idaho (Kochert 1972), and 66 sq mi/pair in Montana (McGahan 1966). Territories of breeding pairs often overlap functionally by the absence of a pair from an area during certain periods; however, the territory is generally defended by the pair from the presence of other adult eagles (Kochert 1972). No attempt was made to delineate territories in the project area. Data from other areas would indicate that the breeding density on the project area is comparable to those observed elsewhere in the intermountain area.

While the territorial behavior of golden eagles would probably preclude large numbers inhabiting the area anyway, incidences of nesting were low during the two years of monitoring. Field observations indicated that several of the inactive eyries located in 1975 had become inactive following a low in the cottontail rabbit and jackrabbit cycles in the region. It has been demonstrated that territories may be smaller during periods of abundant prey and larger when prey is scarce. Consequently, a low incidence of nesting during 1975 would be logical. With the increase in the prey base in 1976 and the expected continued high level in succeeding years, there may be an increase in the incidence of nesting.

All the golden eagles observed actually nesting during the study period produced young birds. A total of four young were observed in the three nests, or 1.33/nest, which compares favorably with data from western Utah indicating a rate of 1.2 young/nest (Smith et al. 1973). As discussed previously, it was felt that one pair of golden eagles may have moved their nesting area to a more remote site; however, no evidence of nest abandonment or failure was observed during the study period.

Bald eagle (*Haliaeetus leucocephalus*): Bald eagles are common winter visitors to the project area, but none were observed during either nesting season. From December through March, however, they were seen almost any day along the White

River corridor. A favorite area for bald eagles is the stretch of river above Hells Hole Canyon. During winter or early spring as many as five have been seen in this relatively small area. After the sheep herds arrive in the winter, bald eagles are often seen feeding on sheep carcasses. In March 1975 bald eagles were observed over a period of days feeding on a dead deer that had washed up on a sandbar above Ignacio. The carcass was eventually completely consumed.

Peregrine Falcon (*Falco peregrinus anatum*): The peregrine falcon is currently listed as an endangered species in the United States (USDI 1976). Three confirmed observations of peregrines were made in April 1975 off the tracts at the mouth of Wagon Hound Canyon by the DWR wildlife biologist (refer to Section IV.B.1 for other transect sightings). All were in the same general area, and were over a short span of time. All three observations may have been of the same bird. No nesting or territorial behavior was observed, and no peregrines were seen during winter. Although habitat for nesting and feeding is available for peregrines along the White River (Behle and Perry 1975), it is probable that the sightings were of a transient bird (or birds). More extensive studies may furnish the information needed to determine the actual status of peregrine falcons in this area.

Prairie Falcon (*Falco mexicanus*): The prairie falcon was listed in the 1973 edition of "Threatened Wildlife of the United States," but not in USDI 1976. They are seen in all areas of the tracts, in all vegetative types and at any time of the year. One active nest containing four young was located in 1975, but the next was inactive in 1976. No active nests were located in 1976, although birds were seen in several areas of the tracts during the nesting season, and several probably old nest sites were located. Prairie falcon habitat is abundant on the tracts (Behle and Perry 1975), with numerous high cliffs and ledges for nesting and large upland and riparian areas for hunting small rodents and birds. Other nests are probably in some of the extremely isolated cliff areas where prairie falcons were observed during the study.

Kestrel (*Falco sparverius*): The American kestrel is the smallest and probably the most abundant raptor on the tracts during spring, summer and fall. During these periods, kestrels are frequently observed in any of the vegetative types of the tracts. They are commonly observed perching on the utility poles and power lines passing through the tracts. Kestrels are generally not seen during the winter in this area, since most kestrels migrate by November and return in early spring.

Kestrels are numerous during the nesting season in the project area. One nest was located in 1976, in a ledge along the White River below Ignacio Stage Stop. The abundance of birds at this time and the extensive cliffs and trees suitable for

nesting found there (Behle and Perry 1975) would indicate that nesting is probably much more common than the one active nest would indicate. The percentage of nests found was small because kestrel nests are inconspicuous, often in old woodpecker holes or in cracks in rock walls, and also because the birds themselves are small and inconspicuous compared with other raptors.

Marsh Hawk (*Circus cyaneus*): Marsh hawks are common, year-round residents of the tracts and can be found in all areas and in all vegetation types on the tracts. While no nests were located during the study, the presence of birds throughout the nesting season and the availability of suitable habitat and rodents would indicate that they do nest in the area. Marsh hawk nests are characteristically in open vegetation types or in low growing vegetative cover such as cattails or bulrushes (Bent 1961). They are not as conspicuous as many other nest types.

Red-tailed Hawk (*Buteo jamaicensis*): The red-tailed hawk, the most common resident buteo in the project area, may be seen at any time of the year throughout the tracts. Nesting is also common in the area. During the study, nests were located along the White River in cottonwood trees and in ledges on cliff faces in the upland areas. Both these types are commonly used for nesting by red-tailed hawks (Bent 1961). A total of four active nests were observed during the study, with an average of 2.25 young/nest. This is consistent with studies in western Utah, which indicated a production of 2.3 young/nest (Smith and Murphy 1973). Field observations of red-tailed hawks indicate that other nests may have been present but were not located because of dense vegetation in the riparian areas. On several occasions, birds were seen displaying territorial behavior during the nesting period, although no nest was located. In one such area, near the mouth of Southam Canyon, an active nest was located by a separate study team working independently of the White River Shale Project (Behle and Perry 1975).

Nesting habitat in the project area is abundant. Red-tailed hawks will use cliffs, cottonwood trees, and juniper trees for nests, all of which are common in the area. Several recently active nests were located in the cliffs north of the White River and in upland areas. Red-tailed hawks do not have extremely large territories, usually 3.9 sq km (1.5 sq mi) (Brown and Amadon 1968), and nesting could be more frequent than actually observed.

Rough-legged Hawk (*Buteo lagopus*): Rough-legged hawks are common in winter on the tracts. These hawks summer north in the arctic tundra (Bent 1961) and migrate onto the area each winter. They are commonly seen hunting in the upland of the project area and along the White River.

Cooper's Hawk (*Accipiter cooperii*): The Cooper's hawk is the most common accipiter in the project area. It is classed as a permanent resident, although sightings are much more common in the warmer months. Generally, Cooper's hawk activities center around the heavily wooded riparian areas of the tracts and adjacent areas, conforming to its character as a woodland raptor.

Nesting by Cooper's hawks in the project area is fairly common. While no nests were located in 1975, two pairs were observed displaying territorial behavior and were therefore thought to be nesting, as reported in the FYEBR. It was later learned from Mike Perry, curator of the Field Museum of Natural History in Vernal, Utah, that he had located an active nest near Ignacio Stage Stop. The number of young in the nest was not determined. In 1976, two active nests were located. Nesting habitat for these hawks is limited to woodland areas (Bent 1961), which are furnished by the abundant riparian areas of the tracts along with a good prey base of smaller birds. The actual extent of nesting in this area is probably greater than that observed because of the difficulty in locating nests, because of the dense vegetation and the presence of nests used by magpies, owls, and other hawks.

Great Horned Owl (*Bubo virginianus*): Although the great horned owl is difficult to observe because of its nocturnal habits, it is a common resident found throughout the tracts, most commonly in the riparian areas.

Great horned owls commonly nest in the project area (Figure IV-25). No nests were located in 1975, as discussed previously. In 1976, however, five nests were located, as listed on Table IV-62. The average number of young per nest was 2.6. This agrees closely with data from western Utah, which indicated a production of 2.5 young/nest (Smith and Murphy 1973). Nesting habitat for great horned owls includes trees, rock ledges, and potholes, all of which are common on the tracts.

Great horned owls do not have large territories. Published figures indicate territories of 260 acres in western Utah (Murphy et al. 1969) and 320 acres in cottonwood river bottoms of Kansas (Baumgartner 1939). With the available critically important nesting sites in the area and the abundance of rodents and rabbits for a prey base, large numbers of owls may inhabit the tracts.

Long-eared Owl (*Asio otus*): Long-eared owl sightings on the tracts during the study were limited. One active nest containing three young was located in 1975. The nest was occupied by a Cooper's hawk in 1976. Bent (1961) reports that alternate use by these two species is common, both being selective for the same wooded habitat types and the same type of tree nest sites.



FIGURE IV-25 GREAT HORNED OWL (BUBO VIRGINIANUS), FEMALE AT NEST ENTRANCE AND THREE FLEDGLINGS.

Long-eared owls confine their activities to the riparian areas along the White River, which furnishes the woodland habitat and abundant rodent populations they require (Bent 1961).

Transect data and field observations have indicated population densities are low; however, because of the dense vegetation, isolation of much of the riparian areas, and the nocturnal, secretive nature of these birds, the incidence of sightings was very low, and it is possible that populations could actually be much higher.

Evaluation of Baseline Program

The raptor studies on the tracts furnished useful information on seasonal use, species present, relative abundance of species, habitat preference, and nesting activities. The differences in weather conditions in the two years of monitoring and the effects of these differences on raptor activities indicate that subsequent years of data would be needed for a complete evaluation of wintering raptor populations.

The study of nesting raptors was felt to be a good indication of nesting activity on the tract and should be included in additional studies. This is especially true in view of data indicating an increasing population cycle of rabbits and rodents, which may allow increased nesting success over the next few years.

The one deficiency in the study was that it failed to yield a good index to population. Although the census counts were useful in indicating population trends, they did not yield absolute population data. If methodologies can be developed by researchers that allow such data to be collected, their use would be recommended in future studies.

f. Cottontail Rabbits

Methodology

The cottontail rabbit study was conducted by the Utah Division of Wildlife Resources as a supplement to their big game studies. This program was not required by the AOSS but was done for the state of Utah records.

Roadside counts of cottontail rabbits were conducted from early June 1976 to late August 1976. A 32-km (20-mi) route was established concurrently with a mourning dove coo-call route from a point in Wagon Hound Canyon to the mouth of Asphalt

Wash. The route was run at intervals of 2-3 weeks throughout the summer. All counts were begun one-half hour before sunrise. The route was driven at 20 mph, and all rabbits observed were recorded. Three-minute stops were made each mile to count calling doves; rabbits observed during these stops were not recorded.

Additional data were obtained through contacts with hunters in the project area. Data recorded included total numbers of hunters, rabbits taken, and hunter days spent in the area, which is consistent with DWR hunter interview programs throughout Utah and provides a base of comparison for hunting quality in the project area.

Summary of Results

As indicated on Table IV-64, cottontail rabbit numbers increased significantly during the study period until a peak was reached on July 29, 1976. At this point, 90 rabbits, or 4.5 rabbits/mi, were observed. This is an increase of 450% over the June 3, 1976 count of 20 rabbits, or 1.0 rabbits/mi. This rapid increase is attributed to the recruitment of young rabbits into the population. Field data from other areas of northeastern Utah substantiate indications that cottontails are in a phase of rapid increase in their population cycle.

In 1976 the project area was used heavily by rabbit hunters. Hunters who had come from as far away as Salt Lake City were contacted. Bag data indicate that although snow cover (normally necessary for good rabbit hunting) was absent during this period (September-December 1976), success was excellent, as seen on Table IV-65. On two occasions parties of four hunters returned to Salt Lake City with limits for two days of 80 rabbits. Most were harvested in Southam and Asphalt Canyons. Even with heavy harvest pressure, however, field observations and hunter contacts during January 1977 indicated the presence of large numbers of cottontails in the area.

Interpretation and Conclusion

The data collected on walking transects in 1975 and 1976 and on roadside counts in 1976 indicate that numbers of cottontail rabbits in the project area increased during summer 1976. Transect data showed an increase in population-density increases of 283% to 6000% in the various vegetation types on the tracts.

Roadside counts demonstrate a pattern of increase through summer 1976. Counts increased from a low in early June of 1.0

TABLE IV-64
HISTORICAL RABBIT DATA
Rabbits Observed/Mile

	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	10 Year Average
Daggett County	1.93	0.81	0.60	0.77	0.76	0.73	0.50	0.24	0.24	0.67	.73
Duchesne County	1.40	0.77	0.68	0.56	0.58	0.24	0.14	0.29	0.67	1.00	.63
Uintah County	1.00	0.98	0.84	1.56	1.39	0.97	0.14	0.19	0.32	1.35	.87
Regional	1.30	0.82	0.68	0.93	0.89	0.60	0.26	0.24	0.43	0.98	.71
Statewide	0.35	0.41	0.32	0.50	0.44	0.43	0.18	0.29	0.22	*	.36
Project Area										4.5	

* Unavailable at this time - 9 Year Average

TABLE IV-65
1976 RABBIT HUNTER DATA

Area	Hunter Days	Rabbits	Rabbits/Hunter
Project Area	22	189	8.6
Uintah County*	41	253	6.2
Duchesne County	58	234	4.0
Daggett County	17	44	2.6
Regional Average	116	534	4.6

*includes project area data

rabbit/mi to 4.5 rabbits/mi in late July, a period of less than two months. As late as August 26, very young rabbits were observed in the area, indicating that recruitment into the population was occurring throughout the summer. This high, continuous recruitment of young is the primary reason for the high population level attained during 1976.

Data collected on other roadside-count routes in north-eastern Utah indicate that rabbit populations throughout the region demonstrated a similar increase. A comparable route in northern Uintah County yielded an index of 1.35 rabbits/mi in 1976, an increase of 422% over the 1975 figure of 0.32 rabbits/mi.

The following observations were made after comparing data from the project area rabbit route with data from other parts of Utah:

(1) Cottontail rabbit populations statewide, region-wide (Daggett, Duchesne, and Uintah Counties), and presumably on the project area, have increased dramatically from cyclic lows in 1973.

(2) Rabbits in the three-county region are at a level in 1976 above the ten-year average and are higher than in any single year since 1967.

(3) The ten-year average of rabbits/mi in the region is approximately double that for the state as a whole, and double that for any other region of the state.

(4) Rabbits/mi on the project area in 1976 had increased 450% over the regional average for 1976.

(5) Rabbits/mi on the project area more than doubled (4.5 versus 1.93), the highest level recorded on any route in Utah during the last ten years.

Cottontail rabbits inhabit all vegetation types on the tracts. The larger drainages and the numerous rocky slopes and outcroppings offer excellent cover and feeding areas. As indicated on Table IV-64, when rabbit populations are high in northeastern Utah, as in 1976, cottontails are extremely abundant in the project area. Comparative data indicate that the project area contains some of the highest populations in Utah, certainly some of the best hunting.

At the present time (1976-1977), cottontail rabbits are in an increasing phase of the population cycle. In northeastern Utah, they reached a low point in 1973-74, and it is probable that the project area experienced a coincident low at this time. Since rabbits normally exhibit ten-year population

cycles (Dasmann 1964), rabbit populations should continue to increase over the next several years.

Evaluation of Baseline Program

Although not required as a part of the baseline program, the cottontail data gathered during the 1975-1976 monitoring period is thought to be adequate to demonstrate baseline conditions of relative densities, patterns of population, and hunting-related activities. As demonstrated by a comparison of historical and 1976 data, these populations are now increasing rapidly and will probably continue to do so.

g. Mourning Doves

Methodology

The mourning dove study was conducted by the Utah Division of Wildlife Resources as a supplement to their big game studies. The program was not required by the AOSS but was conducted for the state of Utah records.

A census of mourning doves was obtained by traversing a call count route using methodology developed by McGowan (1953). The route--the same as that used to count rabbits--was traversed once every two to three weeks during the summer, with a three-minute stop made each mile to count calling doves.

Summary of Results

The mourning dove coo-call route, established on the tracts in 1976, was traversed from early June until late August at approximately two-week intervals. The peak number of calls heard was on June 28, 1976. Numerous calling was evident throughout June. By the end of July, however, calling had almost ceased.

At the peak of calling on June 28, thirty-one doves were heard, for a density of 1.55 per station (20 stations). Data for the state of Utah indicate a ten-year statewide average of 15.7 calling birds per route (Table IV-66), or 0.79 per station. Some bias is inherent in this comparison because of weather differences between years. Also, statewide routes are conducted in late May, and data from the study indicate that the peak of calling doves does not occur until late June.

TABLE IV-66
HISTORICAL COO-CALL DATA

	Doves Herd/Route											
Route	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	10 Year Average
Deadman Bench	--	17	33	38	15	66	4	18	12	7	27	23.7
Dragon Canyon												
Statewide												
Average	13.5	19.7	15.2	14.3	13.4	22.7	14.3	12.8	19.3	12.1	*	15.7

*unavailable at this time

TABLE IV-67
HARVEST DATA - MOURNING DOVES

Year	Hunters*	Birds Bagged	Hunter-days	Birds/Hunter Day
1975	16	121	18	6.7
1976	8	6	8	0.75

* Hunters contacted in the area

Additional data are available for comparison from a DWR route from Deadman Bench 8 km (5 mi) north of Bonanza and south along Utah-45 to the mouth of Dragon Canyon. This route has averaged 23.7 doves per route, or 1.19 per station, over the last ten years, which is higher than the statewide average. On May 28, 1976, 27 doves were heard on this route compared with 25 doves heard on June 3, 1976, on the tracts. With the geographical proximity, habitat similarities, and agreement of 1976 data, the correlation of data between the routes should be true in a given year.

During September 1975 and 1976, mourning dove hunters were contacted in the Bonanza area and in the project area in an effort to determine hunter success, harvests, and hunting pressure. Table IV-67 lists data from the two years.

Interpretation and Conclusions

A formula for estimating the number of mourning doves from coo-call data was proposed by Lowe (1956) as an index of breeding birds. It was determined that calling birds at each listening station were audible over an area of 60.7 ha (150 acres). The total area surveyed by each route would then be 1214 ha (60.7 ha x 20 stations). At the maximum level of calling activity in 1976 the density of calling birds was calculated as follows:

$$\frac{31 \text{ doves heard}}{121 \text{ ha}} = 0.03 \text{ doves heard/ha}$$

Lowe determined that the detection level of actual doves present was 1.74 breeding pairs per calling bird. The total number of breeding birds present, using this factor, would then be 0.03 doves heard/ha X 1.74 pairs/doves heard - 0.4 pairs/ha. Total breeding birds present would then be 0.08/ha. Since the route encompasses all the vegetation types present, this figure would be the average for the tracts as a whole.

Data gathered from walking transects in June 1976 (see Section IV.B.1) indicate that mourning dove densities per ha were 0.5, 0.5, 0.2, and 1.6 in the sagebrush, juniper, shadscale, and riparian vegetation types, respectively. These densities are higher than those indicated by call counts because transect counts would include non-breeding birds and young of the year in the estimate.

Studies correlating the calling of mourning doves with the chronology of breeding activities are contradictory. Lowe (1956), McClure (1939), and McGowan (1953) all indicate that the highest level of calling corresponds with the peak of

breeding activities; however, later studies (Frankel and Baskett 1961; Jackson and Baskett 1964) concluded that males did very little calling during the nesting and brooding periods.

Instead, non-mated males, or those between nesting periods, called much more frequently and were thus responsible for most of the calls heard. If the latter is the case, then the June 28 peak of calling would be interpreted as a period of non-mating. Considering the short time required for doves to produce young (McGowan 1953) and their almost universal tendency to bring off multiple broods during the summer, it is probable that this peak is between two nesting periods.

Hunter bag checks in the project area and observations by DWR personnel over a period of years indicate that hunter pressure and kills are not directly proportional to population levels of breeding doves in this area. Instead, weather conditions during August seem to be a more definite regulatory mechanism. August 1975 was a warm, dry month, and subsequently, dove hunting in early September was excellent in the area. In August 1976 there was a period of cold, near freezing nights, and by September 1 (the opening day of dove season) most of the birds had left the area. Consequently, while breeding levels were similar during the two years, dove hunting in 1976 was very poor compared with that of 1975. Relatively few hunters use this area compared with similar areas near population centers.

Evaluation of Baseline Program

Many variables influence the year-to-year mourning dove populations in the project area. Nesting success is highly dependent upon the weather conditions during the nesting cycle. Unseasonably cold weather can seriously decrease nesting success. Additionally, the migratory nature of the birds makes even their presence in the area variable. A cold period in August can result in almost the entire population migrating south. Consequently, data collection of both the walking transects and coo-call count route would need to be collected over a period of years to establish baseline information.

h. Livestock and Feral Horses

Methodology

Information concerning sheep and cattle activities on the tracts was obtained from BLM grazing permits and from Cole (1958 and 1963) browse use transects. Feral horses were to be studied if they were sighted.

Eight browse-use transects were established in each vegetation type in areas of known livestock and deer use--in big sagebrush, greasewood, and rabbitbrush--to determine preferred browse areas. Each transect consisted of 24 plants of the same species at approximately 15-m intervals. The percentage of use was determined by a visual estimate of the current year's growth used compared with the growth available. Browse use for cattle and deer was determined in riparian areas, and for sheep and deer, immediately after the last sheep were driven off the tracts. This methodology is described in more detail in the Partial Exploration Plan.

Summary of Results

No feral horses were seen on or near the tracts during the study.

The BLM permits cattle grazing in the riparian area of the White River from Asphalt Wash to Hells Hole Canyon for a total of 790 animal units per month (AUM's). In 1975 and 1976 approximately 160 head of cattle were grazed from June 1 to October 31.

Sheep grazing on the tracts is limited to three allotments and only during winter. Between December 16 and April 30, 1975 and 1976, approximately 1800 sheep were grazed in the Southam Canyon area. The second allotment permits grazing to 2650 sheep, or 1865 AUM's, between January 1 and April 15 from Ignacio to Hells Hole Canyon and the uplands south of the river. The third allotment is in the Wagon Hound area from Evacuation Creek to Station S-4 (north of Tract U-a). This permit allows grazing for 2500 sheep from March 15 to April 20 for a total of 585 AUM's.

The areas used and their seasonal use by cattle were the same during both years. Cattle arrived in the area June 1 and left October 15. Sheep use during the winter of 1976-1977 was curtailed because of a lack of snow cover for water. Conditions deteriorated to the point where some sheepherders were trucking water to wintering sheep in January. This created a very poor pattern of dispersal, with areas around available water being very heavily used, and more isolated areas relatively untouched.

Interpretation and Conclusions

Livestock (sheep and cattle) are permitted on various portions of the project area during every month of the year except May and November. Summer use is restricted to cattle grazing on the White River riparian area and adjacent uplands. Winter

use is restricted to sheep grazing on three allotments contained primarily within the project area.

During summer, cattle graze mainly the riparian areas along the White River, which provide water and abundant feed and shade during the hot summer months. During June, July, and August, cattle are rarely seen outside the riparian area. By late August and through September and October, as available forage along the river is consumed, cattle are often seen in the upland areas north and south of the river where they feed on some grasses and browse species. Although cattle will wander as far away as Bonanza, they still depend on the river for water.

Precipitation during the 1975 growing season was above average, and consequently forage production was excellent. When the cattle left the area in October, both grass and browse forage were still available. Sheep use was initiated one month later in December. By this time, two substantial snowstorms had occurred and good snow cover was present. Distribution of sheep during the winter was good. When browse utilization studies were conducted in late spring of 1976, no transect showed higher than 47% use of sagebrush or 51% of greasewood.

Browse-use transect data were better indications of sheep activity than of cattle activity, since cattle use is confined mainly to grasses along the riparian areas. At the 95% confidence level, it was determined that greasewood (*Sarcobatus*) was used more on Tract U-a than on both tracts, and that sagebrush (*Artemisia*) was used about equally on both areas. Field observations have shown that sheep forage heavily in the bottoms of the larger drainages (e.g., Southam and Asphalt), and pellet group data also show significantly higher deer use outside of Tract U-a; therefore, the equal use of sage can probably be attributed to lower sheep use and higher deer use outside Tract U-a.

The 1976 growing season on the tracts coincided with a record-breaking drought in Utah. Field observations indicated greatly reduced forage production from 1975. Drought conditions continued through 1976, and after initial growth in late spring, no subsequent growth of forage was seen. Although forage production was much lower in 1976, the full allotment of cattle were grazed during the year. Sheep grazing was reduced during the winter of 1976-1977 because of a lack of snow cover to furnish water.

The ultimate effects of this drought period have yet to be fully assessed. As of March 1977 the drought was still critical. The long-term effects of this condition on these already poor ranges must be assessed in terms of stocking rates and seasonal use.

Evaluation of Baseline Program

In the baseline program, the studies of livestock use on the tracts was limited. Browse transect data on key browse species indicated winter sheep use but not of cattle use in the riparian areas. Summer cattle use is largely confined to grasses, and much of it is during the period when active growth is still occurring, and therefore it was felt that an analysis of cattle use would be beyond the scope of the project.

Attempts to take aerial photographs of wintering sheep on the tracts was impossible because the sheep were scattered over wide expanses of broken terrain, and therefore actual counts were not obtained. Accurate counts by aerial photographs are probably impossible, since the sheep apparently always scatter this way. The same is probably true for cattle, because of the dense vegetation in the riparian areas. If in the future studies an accurate count of wintering sheep and summering cattle is needed, it should be obtained by contacting the livestock owners, because BLM records of numbers and seasons of use are probably not as up-to-date as those of the operators themselves.

i. Beaver

Methodology

Beaver food caches were counted during float trips in the late fall. The number of caches per kilometer is considered an indication of activity and population. This method was useful in determining fluctuations in population size but not in determining the actual number of beaver present.

Summary of Results

Bank dwelling beaver are common along the White River on the tracts. In many sections of the riparian areas, beaver have extensively pruned young cottonwood trees. In the 1975 float trip, 57 beaver food caches were observed, indicating a winter cache concentration of 2.0/km (3.2/mi) of river as measured along the meanders from stations S-1 to S-11. A fall cache count was conducted in September 1976 in which 52 caches were observed--ten caches above the Ignacio bridge and 42 below it.

Interpretation and Conclusions

Fall cache counts on the White River indicate that the beaver population in this area is relatively stable. The counts in 1975 and 1976 offer no indications of any trend in populations.

The following conclusions were made after field observations of cache construction and feeding areas along the river:

(1) The beaver population is probably stable at this time, as indicated by the uniformity of cache counts during the two-year period.

(2) The population is at or very near the carrying capacity for this ecosystem, as indicated by extensive cutting of forage species for feeding and cache construction. Many areas along the river have been practically denuded of desirable food species of a usable size. In many of these areas cutting is recent enough that regrowth of usable stems has not yet occurred. Also, beaver trapping in the Uinta Basin is at an extremely low level and has been for several years because of the current low prices being paid for beaver pelts and the remoteness of the area. Consequently, populations have increased, limited only by natural mortality, which in this ecosystem is probably slight.

Beaver populations are usually estimated by calculating five beaver per cache (UDWR 1960). It is assumed that each lodge has a corresponding cache and that the average lodge houses five beaver. If 5 is used as the factor, 285 (1975) and 260 (1976) beaver are present.

These figures must be considered rough estimates, because of the difficulty in estimating the particular population. White River beaver are bank dwellers, not lodge builders, which makes the formula based on the number of caches hard to use. Also, the extreme fluctuations in water levels in the river, especially after rainstorms and their heavy silt loads, make it difficult to determine which caches are fresh and which are abandoned. Field observations have indicated that the estimates are biased toward higher numbers, since in some areas several small caches were seen that were insufficient in size to winter a colony of five beaver; however, they have also indicated that the estimates could be fairly accurate. On spring float trips from stations S-1 to S-11, when beaver are active, as many as 20 to 30 have been seen, even during the middle of the day, indicating a large population of these nocturnal and rather secretive animals.

Evaluation of Baseline Program

As described previously, many characteristics inherent in the White River system make an actual population estimate for beaver difficult. The cache counts that were conducted, when viewed in light of observed field conditions, seem adequate to provide a relative index of populations. Changes in beaver populations as a result of oil shale development should be evident in changes in this index if these counts are made through the operation period.

C. TERRESTRIAL INVERTEBRATES

Terrestrial invertebrates were studied on the tracts to obtain an overview of arthropod diversity by compiling lists of taxa and by listing spatial and temporal distribution and density of the more abundant and important species. An objective of the program was to determine species food habits from general observations and from literature review.

1. METHODOLOGY

Arthropods were collected on the tracts and a 1.6-km perimeter from May to September in 1975 and 1976. During 1974 and 1975 species were identified and classified. Quantitative collection and analysis was conducted in 1976.

The methods of collection and identification are detailed in the First Year Environmental Baseline Report (FYEBR) and in the Partial Exploration Plan as revised May 19, 1976. Basically, collection techniques included netting by sight; sweeping vegetation; searching under bark, stones, and other hidden locations; malaise and light trapping; and Berlese funneling of litter (Figure IV-26). Heavy reliance on collecting from flowers and herbage probably resulted in an overall bias favoring Hymenoptera, Diptera, Hemiptera, and Homoptera. Greater emphasis on rearing and collecting at night probably would have improved the balance by increasing the representation of Lepidoptera and Coleoptera.

Dr. Bohart and other entomologists at Utah State University identified many of the insects, but the majority were sent to various specialists in the U.S. and Canada. In many cases the specialists identified much or most of the material only to the generic (or sometimes even higher) level. Occasionally they indicated the species involved by number (1, 2, 3, etc.), but in most instances this was left to Dr. Bohart. The various specialists (and their institutions) involved are listed on Appendix IV-8.

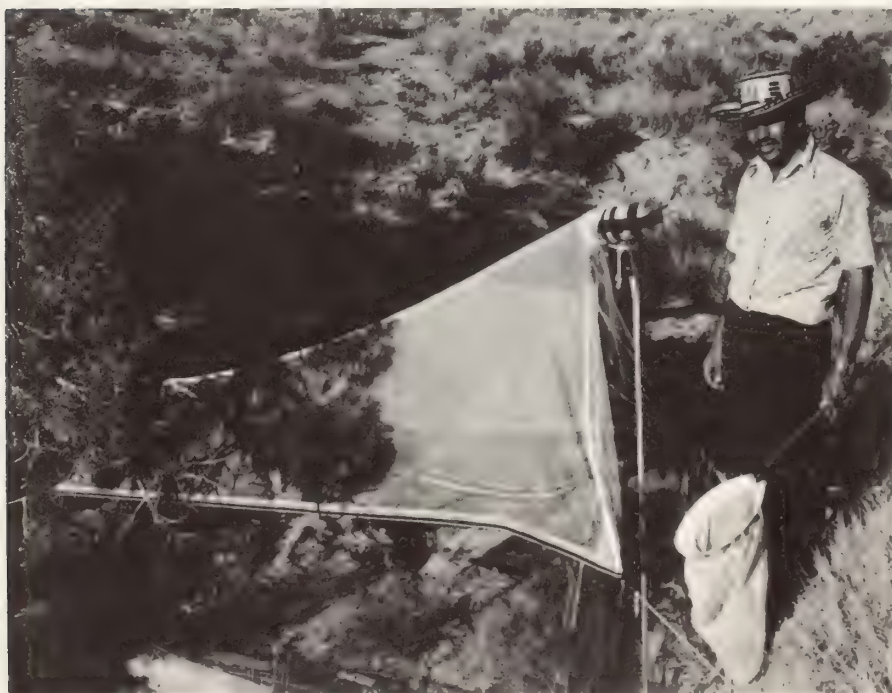
The species collected and identified in the baseline program are listed on Appendix IV-9. The species are arranged according to An Introduction to the Study of Insects, by Borror and De Long (1970). Several groups (weevils, encyrtid wasps, microlepidoptera, etc.) have not yet been returned, and therefore the number of species is an estimate only. Additional information, such as descriptions of the insects and their food preferences, is given on Appendix IV-10.

Arachnids were not studied extensively for the baseline program because the special requirements involved in collecting,

FIGURE IV-26
TERRESTRIAL INVERTEBRATE
COLLECTION METHODS



"Sweeping" juniper in upland belt. Fifty sweeps per sample.



"Malaise" trap located over gully (insect flyway).
Insects contact center partition, move upward to
ridge, upward along ridge to cyanide bottle.

handling, and mounting these species were beyond the scope of the project; however, since these species are abundant on the tracts, they are included based on what is known of them in the area.

Over two thirds of the species listed on Appendix IV-9 were collected along the White River and Evacuation Creek. Along the stream courses the plant species most attractive to the most insect species were western virgin's bower (*Clematis linguisticeifolia*), rubber rabbitbrush (*Chrysothamnus nauseosus*), saltcedar (*Tamarix pentandra*), and white sweet-clover (*Melilotus alba*). Next in order were willow (*Salix exigua*), greasewood (*Sarcobatus vermiculatus*), and big sagebrush (*Artemisia tridentata*). Attractive but not abundant enough to be significant were Rocky Mountain bee plant (*Cleome serrulata*), pepper-grass (*Lepidium montanum*), and gumwood (*Grindelia squarosa*). Skunkbrush (*Rhus trilobata*) and cottonwood (*Populus* spp.) provide important cover for adults of many aquatic species and provide an exclusive habitat for a few plant-feeding terrestrial forms.

In the uplands area, saltcedar is scarce, but when in bloom, it is exceptionally attractive to many flower-visiting insects. Blooming stands of rubber rabbitbrush and sticky-flower rabbitbrush (*C. viscidiflorus*) both attract a wide variety of insects in the uplands areas. Shadscale (*Atriplex* spp.) and sagebrush have distinctive faunas but do not attract as great a diversity. Serviceberry (*Amelanchier*), ocean spray (*Holodiscus*), and skunkbrush are examples of shrubs with relatively few insects on them, but these few insects are often specific to that plant genus.

Aquatic orders (Odonata, Ephemeroptera, Trichoptera, Plecoptera) and families (Coleoptera, Diptera, and Hemiptera) were not intensively collected, since they were being studied in the aquatic biology program.

2. SUMMARY OF RESULTS

In the baseline program, insects were given the most emphasis because they constitute the overwhelming majority of terrestrial arthropods.

Although the area did not appear to be particularly rich in insect life, the number of species collected (over 2200) by one person in less than 30 days of actual collecting compares favorably with the 1129 species collected at the Deep Canyon Desert Research Center near Palm Springs, California (Edney 1974), or the 2064 species collected at Craters of the Moon National Monument in Idaho (Horning and Barr 1970). The diversity of arthropods at these locations are compared on Table IV-68.

TABLE IV-68

COMPARISON OF ARTHROPOD DIVERSITIES AT FOUR LOCATIONS*

ARTHROPOD ORDER

-----LOCATION-----

	Tracts U-a and U-b	Deep Canyon**	Craters of*** The Moon	Pawnee**** Grassland
Araneida (spiders)	23	25	-	34
Collembolla	29	0	6	12
Diplura	1	0	0	0
Thysanura	2	3	2	1
Ephemeroptera	4	1	4	3
Plecoptera	2	2	5	0
Odonata	10	6	10	10
Dermaptera	0	3	1	0
Orthoptera	29	18	23	72
Isoptera	1	0	1	2
Psocoptera	1	0	3	5
Anoplura	0	0	0	1
Thysanoptera	12	27	10	17
Hemiptera	83	31	115	114
Homoptera	130	48	79	160
Trichoptera	6	4	12	3
Lepidoptera	149	118	218	105
Neuroptera	14	32	24	8
Megaloptera	0	2	0	0
Coleoptera	281	213	324	531
Siphonaptera	0	0	0	1
Diptera	647	354	521	269
Hymenoptera	809	267	705	302
TOTAL INSECTS	2210	1129	2063	1616

*Localities roughly comparable in size.

**Desert canyon with stream near Palm Springs, California.

***Semi-arid shrub land with stream near Arco, Idaho.

****Tall grassland near Pawnee, Oklahoma.

The number of species of minute parasitic Hymenoptera was particularly impressive. Unfortunately, it was impossible to get many specific determinations among the chalcidoid, cynipoid, and proctotrupoid wasps. Due to inadequate staffing, the USDA specialists at the U.S. National Museum recently have had to adopt a policy of making determinations of parasitic Hymenoptera only when the material is reared and accompanied with positive host records.

Several insect orders not represented in the species list are unquestionably present in the area. Many of these are ectoparasites of birds or mammals, for which no search was conducted. Members of the order Mallophaga (chewing lice, or bird lice) spend their entire life cycle on the hosts (more commonly birds than mammals). Members of the order Anoplura (sucking lice) are restricted to mammals. Domestic animals are frequent hosts of both orders, many of Anoplura only. Members of the order Siphonaptera (fleas) feed as adults on the blood of birds and mammals (especially on the latter). On the tracts they are probably most abundant and diverse on rodents. Several non-parasitic orders not represented on the list are probably absent in the area. These include Protura, Embioptera, Zoraptera, and Mecoptera. The remaining unrepresented order, Dermaptera (earwigs), generally inhabit warmer climates, although the common European earwig may be present.

Several important insect families not on the species list but present in the area are ectoparasites of birds and mammals. These include Hippoboscidae (louse flies), on birds and some mammals (notably sheep), and Streblidae (bat flies), on bats. Cimicidae (bed bugs) are probably found in the swallow's nests. Several dipterous families that are endoparasitic on mammals as larvae probably also occur on the tracts, including Cuterebridae (rodent bots), Oestridae (warble flies), and Gastrophilidae (horse bots).

The quantitative data taken on insect populations during the course of this project are in the field data package on file in the AOSS office. They detail the results of sweep samples made on a total of 30 species of plants during June, July, August, and September 1976. Each sample includes insects from 50 sweeps with a 12-in.-diameter insect net passed through plants of a particular species. From 15 to 18 plant species were sampled each month, and in each month certain species were sampled at two different locations. In July and August, one species, rubber rabbitbrush, was sampled at the same locations in a blooming and in a non-blooming stand.

The field data tables include data from a total of 3550 sweeps, which yielded 15,667 insects, or 414 insects per sweep. There was a total of 72 species (0.20 species per sweep, or 1 species per 21 insects collected). The 720 species represent 33% of the approximately 2200 species collected in the general survey.

A complete list of the insects in the four tables follows the tables themselves. To facilitate reference to specific tables, this list includes the months in which the various insects were sampled.

Several classes of elongate terrestrial arthropods, at one time lumped under the term Miriapoda, are represented in the area by at least the classes Diplopoda (millipeds) and Chilopoda (centipedes). Both are found in organic soil, leaf litter, under stones, in decaying wood, and under dead bark. The former is phytophagous, and the latter is predaceous. Probably not more than three or four species of each occur on the tracts. The other miriaropod classes, Pauropoda (*Pauropods*) and Symphyla (*Symphylans*), are found in similar locations, but are relatively uncommon. They are probably present in the area, but none were observed.

Terrestrial members of the class Crustacea are represented on the tracts by the order Isopoda. The two well-known groups of isopods -- sow-bugs (*Oniscus*) and pill-bugs (*Cylisticus*) -- are present in damp places under logs or loose bark. They feed on roots and tender plant parts close to the ground and sometimes cause considerable damage.

Arachnids, including spiders, mites, ticks, centipedes, millipedes, and the like, were studied through limited collection and identification (Figure IV-27). Arachnids are abundant and moderately diverse on the tracts, and the 22 species listed represent only a fraction of those actually present in the area. A number of other species not listed were collected, but these have not been identified.

Most species on the tracts are found on herbs, shrubs, or trees, although many are in the soil and leaf litter, under stones and loose bark, and in other hidden places. Among the well known (and often feared) types in the area are black widows (*Latrodactes*) and Tarantulas (*Theraphosidae*). The former are abundant under rocks along road shoulders, and the latter are only assumed to be present because of the presence of *Pepsis*, a Tarantula-hunting wasp. Black widows are probably the only dangerously venomous (but seldom fatal) spider in the area. The most conspicuous spiders on the tracts are the Thomisidae, which lie in wait on flowers for their insect prey, and Salticidae, which pursue their prey in the open and frequently jump when disturbed or when pouncing.

Mites (*Acarina*) are a common, generally minute arachnid usually found in soil litter, fungi, insect nests, and on insects themselves; as ectoparasites on birds and mammals; and on various plant hosts, where they often spin webbing or induce gall formation. It is probable that several hundred species could be collected on the tracts. There are relatively few ticks (a large form of mite ectoparasitism on mammals) in the



Scorpion (undetermined). Abundant under flat stones by "duck" formation. Feed on medium-sized to large arthropods. Forage at night.



FIGURE IV-27
ARTHROPOD
PHOTOGRAPHS

Black widow spider female (Latrodectes sp.) Ventral side, showing "hour-glass" marking. Common under flat stones in sheep drive areas. Feed on arthropods entering web and within several inches.



Snowy tree cricket (Oecanthus) on rabbit brush. Evening song. Feeds on petals and leaves. Very abundant near stream courses.



Striped locust (Melanoplus bivittatus) mating pair on rabbit brush. Commonest grasshopper in more densely vegetated areas.

FIGURE 1
(CON'T)



Orb spider (*Araneus* sp. male). Large pedipalps and long front legs denote males (which don't make orb webs).



Wolf spider (*Lycosa* sp. female). This species forages by day on sand along stream courses. Does not spin web except to line hole.

FIGURE 1
(CON'T)



Robber fly (Promachus aldrichii) with grasshopper (Melanoplus sp.) prey.



FIGURE IV-27
(CON'T)

Green lacewing (Chrysopa sp.) Adults and larvae feed on aphids and other soft-bodied insects. Eggs provided with long stalks.

area, but they are still a nuisance and are important disease carriers.

The only other arachnid orders known to be on the tracts are Pseudoscorpionida (pseudoscorpions), Solpugida (sun spiders), and Phalangida (harvestmen, or daddy-long-legs). Pseudoscorpions, which feed on mites, are found in decaying wood or leaf litter. Sun spiders, which prey on insects, are found in sandy soils. Phalanids prefer moist, shady places and prey on small insects or on dead ones, depending on the species. Of the arachnids, only mites and spiders are represented on the tracts by more than a few species.

3. INTERPRETATION AND CONCLUSIONS

Several generalizations concerning insects on the tracts can be made from the species list, the tables detailing the results of the survey samples, and the characterizations of insect families included in the preceding section. Comparisons from month to month for 1976 show that the total number of insects in the samples was 2568 in June, 3505 in July, 2334 in August, and 7260 in September. The last figure is somewhat inflated because it includes 23 samples instead of the 18 samples included for the other months. Corresponding comparisons for species are 241 in June, 367 in July, 300 in August, and 314 in September.

During the 1976 monitoring period the population levels increased 50% from June to July, dropped to the June levels in August, and increased in September to about twice the July levels. In 1976 rainfall intensity and frequency was less than in 1975, resulting in a much drier growing season in 1976, and therefore the increase from June to July 1976 was surprising, since in a dry year populations generally decrease.

The relatively high number of species in July was probably due in part to the three samples from rubber rabbitbrush (one in bloom). The total number of species for the four sampling dates (721) is over twice that for any one date and 500 less than the total number of species. For example, there were usually few insect species on juniper (except for an abundance of minute parasitic Hymenoptera in June) and there were usually dense populations on rubber rabbitbrush. In June, willow and saltcedar were swept side-by-side. The tamarix had 391 insects compared with 134 for the willow, and 41 species compared with 31, respectively. Moreover, only five species were taken from both plants, and three of these were aquatic or semi-aquatic that were using the plants merely for cover.

The drop in August probably reflected the continued drying

effect on the vegetation. The increase in September represented a resurgence following a few late summer rains and the heavy populations on blooming rubber rabbitbrush and wild buckwheat (*Eriogonum*) that occur every year. It also reflected the extremely high populations of Chironomid midges (1500) that were found in one sample from saltcedar along the White River at that time. These midges had emerged from the river and were taking shelter (perhaps gregariously) in ideal cover.

Similarities and differences between the insect fauna of plant species were often obscured by location and by the presence or condition of bloom. In general, a species of plant sampled along the White River or Evacuation Creek was richer in the number of insects and insect species than the same plant species sampled in the drier upland areas. This difference tended to be accentuated as the season progressed. For example, in June the number of insect species from the White River bridge and from Southam Canyon was about equal on rubber rabbitbrush, but in September twice as many insects and species were taken at the White River on rubber rabbitbrush.

The condition of bloom was even more important than location for most plant species. For example, in early July an unusually early bloom appeared on a small stand of rubber rabbitbrush in Southam Canyon. When sampled, it had about four times the insect population and nearly three times the number of species as a non-blooming stand sampled nearby. In early August the same comparisons could be made on other stands of rubber rabbitbrush (*C. nauseosus*) at Southam Canyon. This time the population on the blooming stand (130) was somewhat over twice that on the non-blooming stand (61), and the number of species (29) was only 5 more than that on the non-blooming stand (24). In this instance a general drying condition during July was probably responsible for the relatively poor showing on the blooming material. Western virgin's bower in full bloom in early August yielded 547 insects of 121 species. The same plants, still green but out of bloom in September, yielded only 69 insects of 25 species. On July 8 ocean spray in bloom yielded 135 insects of 49 species. In September, when out of bloom, it yielded 85 insects (nearly all of one leafhopper species restricted to ocean spray) of only 6 species.

Some species of insects were found exclusively or primarily on one host plant or a few related host plants. Leafhoppers (*Erythroneura aspera*), for example, were taken almost exclusively on ocean spray but a few were found on another rosaceous shrub, serviceberry, a few meters away. Jumping plant lice, (*Calophya triozae*), were abundant on skunkbrush in upland and riparian areas. The five specimens recorded from serviceberry in September were probably *Trioza* sp., a similar form associated with that plant. Leaf-feeding beetles (Chrysomelidae, Curculionidae, and some Cerambycidae) also tended to be host specific.

Most insect species were found on a wide selection of plants. Many predaceous and parasitic insects, for example, moved from one plant to another to take advantage of a blooming condition or to avoid a drastic drying condition. Thus, on one sampling date, they might appear to exhibit a strong host preference, but on another one they would appear to have no host preference. Most of the species sampled were taken in such small numbers that it would be difficult to determine their plant preferences.

Many species of bees are noted for their strong preference or exclusive attachment to a single genus of host plant for pollen supplies. The sampling program yielded a great many bee species, but not enough of any one to determine their pollen selection. Enough samples of the genus *Perdita*, known particularly for its narrow pollen selectivity, were taken on several occasions, but with no particular specificity. For example, *Perdita* no. 1, on September 10, was literally swarming in both sexes on rubber rabbitbrush and on the unrelated wild buckwheat. *Perdita similis* and *P. caloleuca* were also taken in both sexes on both plants. Although this did not invalidate the fact of *Perdita* selectivity, it did represent an exception to the general rule.

4. EVALUATION OF BASELINE PROGRAM

The data generated in the baseline study fulfilled the objectives of the program. They provided a general frame of reference for describing the number of insect species, plant selection, and population levels in the area; however, they did not provide a reliable base for estimating the populations of any particular species.

D. AQUATIC BIOLOGY

Aquatic biota were sampled along the White and Evacuation Creek. The purpose of the program was to determine species composition, diversity, spatial and temporal distribution, relative abundance, and productivity.

1. METHODOLOGY

The methodology used in the aquatic biology program is outlined in the Partial Exploration Plan, revised May 19, 1976; Quarterly Report No. 4; and other documents. The program is summarized as follows:

Station locations were selected on the basis of their relationship to tributaries, lease boundaries, and accessibility (refer to Figure IV-2). Each station included a section of stream approximately 300 m (985 ft) long and a variety of habitat or stream conditions, such as pools, riffles or rapids, backwaters, etc. Samples of the same type were taken from identical locations at each sampling station as much as possible. The stations were placed as follows:

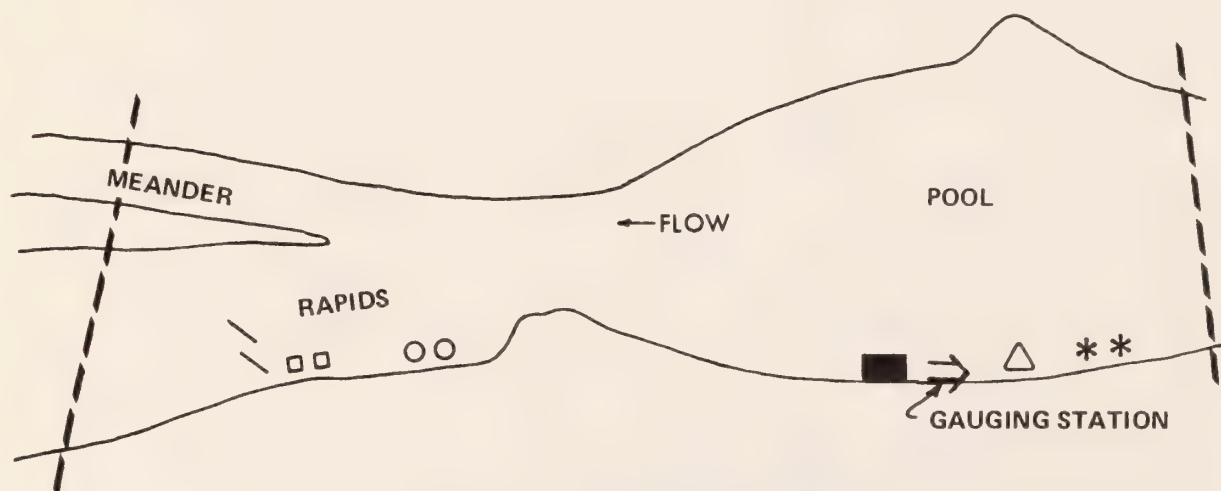
F-1	White River	Hells Hole Canyon
F-2	White River	Downstream of Evacuation Creek
F-3	White River	Downstream of Bonanza Bridge
F-4	White River	Southam Canyon
F-5	White River	Asphalt Wash
F-6	Evacuation Creek	above Highway 45 Bridge

Figures IV-28 through IV-35 illustrate the various sampling locations for each station on the White River.

Major sampling was conducted in March or April and from August through November during both years. The river is generally covered by ice from December into March, making sampling difficult or impossible. Snow runoff begins in May and continues through mid-July. During this period, specific sampling sites were often inaccessible or could not be sampled by routine methods. Invertebrate and fish populations were usually dispersed and algae scoured away during these periods anyway.

Plankton samples were collected in duplicate with a handheld No. 16 mesh plankton net and a Wildco No. 1120 alpha type of sampler. Samples were preserved in 4% formalin with two drops of glacial acetic acid per 100 ml. The netted plankton samples were examined for identification of specimens, and the alpha samples for enumeration. Identification was to the lowest practical taxon, in accordance with the approved Partial

F-1 (DIAGRAMMATIC)



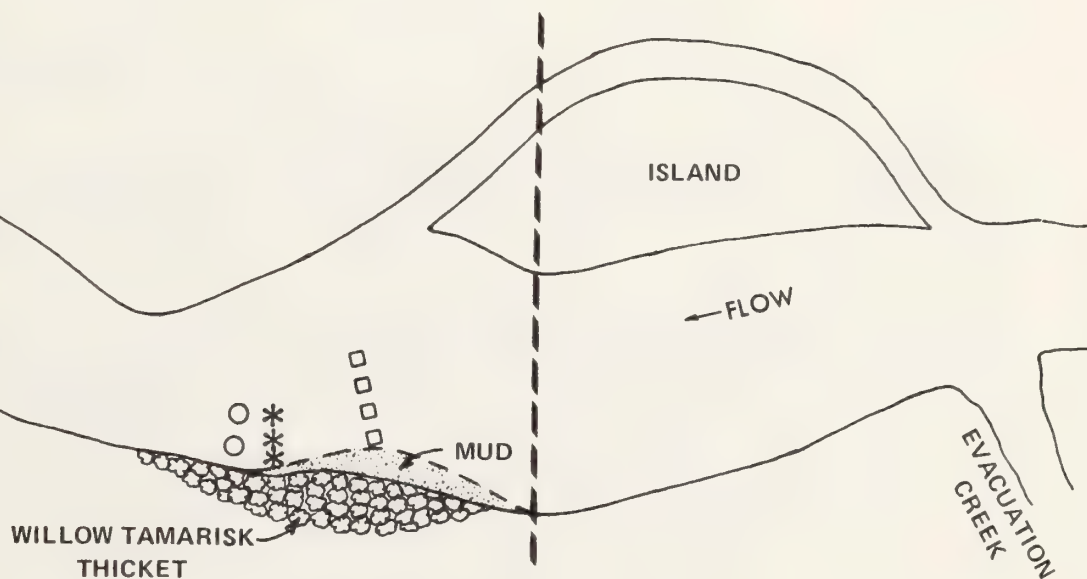
-  STATION LIMITS
-  PLANKTON SAMPLES
-  EKMAN SAMPLES
-  SURBER SAMPLES
-  HANDSCREEN SAMPLES
-  SEINE SAMPLES
-  PERIPHYTON SAMPLER

STATION F-1 SHOWING VARIOUS SAMPLING LOCATIONS

FIGURE IV-28



F-2 (DIAGRAMMATIC)



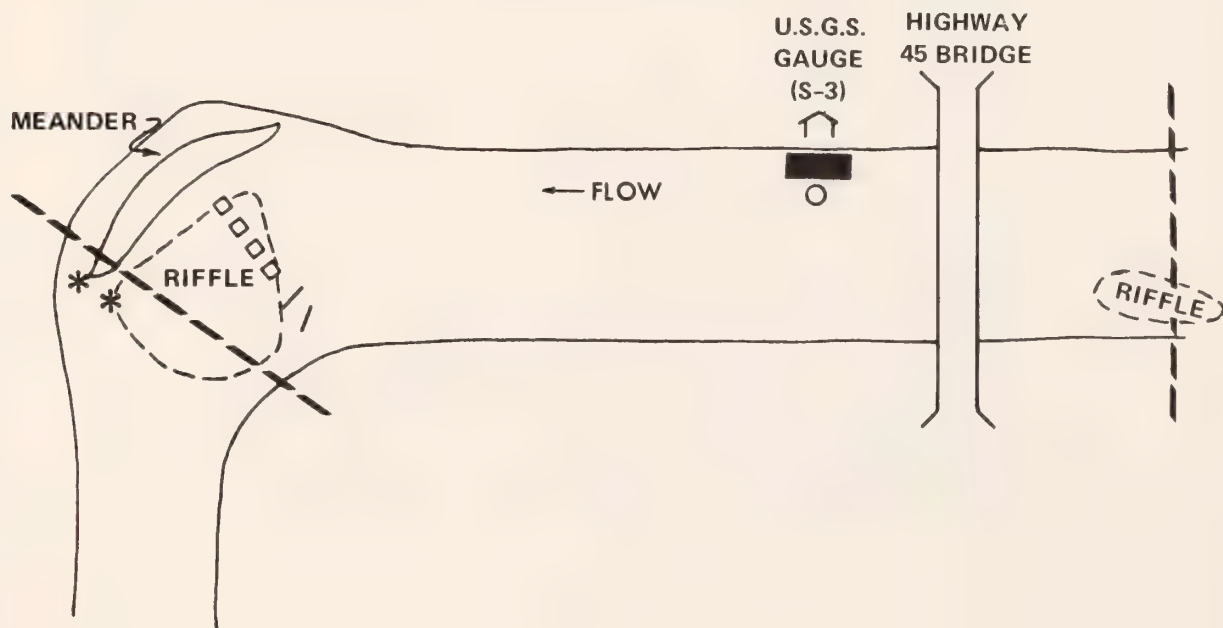
- STATION LIMITS
- PLANKTON SAMPLES
- * EKMAN SAMPLES
- SURBER SAMPLES
- △ SEINE SAMPLES



STATION F-2 SHOWING VARIOUS SAMPLING LOCATIONS

FIGURE IV-29

F-3 (DIAGRAMMATIC)

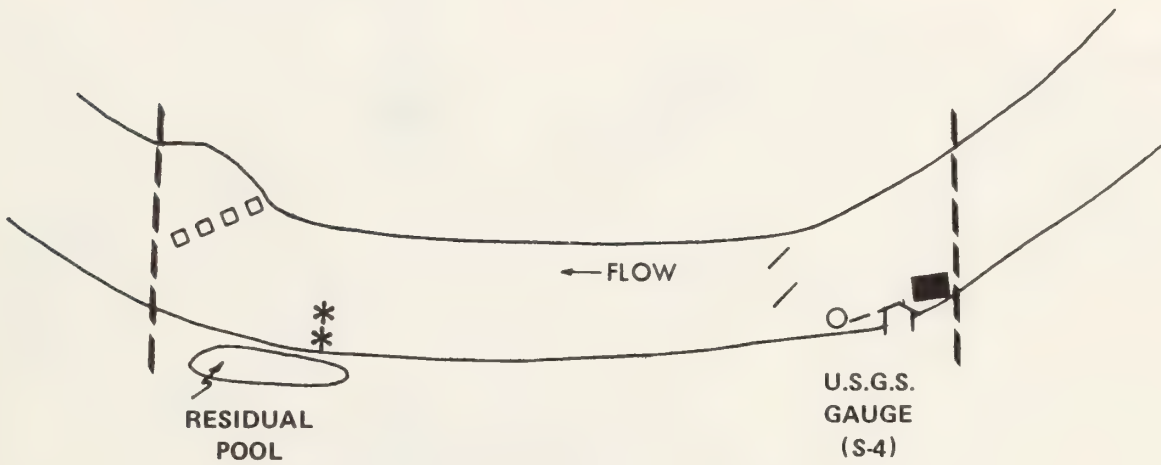


- STATION LIMITS
- PLANKTON SAMPLES
- * EKMAN SAMPLES
- SURBER SAMPLES
- / HANDSCREEN SAMPLES
- PERIPHYTON SAMPLER

STATION F-3 SHOWING VARIOUS SAMPLING LOCATIONS

FIGURE IV-220

F-4 (DIAGRAMMATIC)

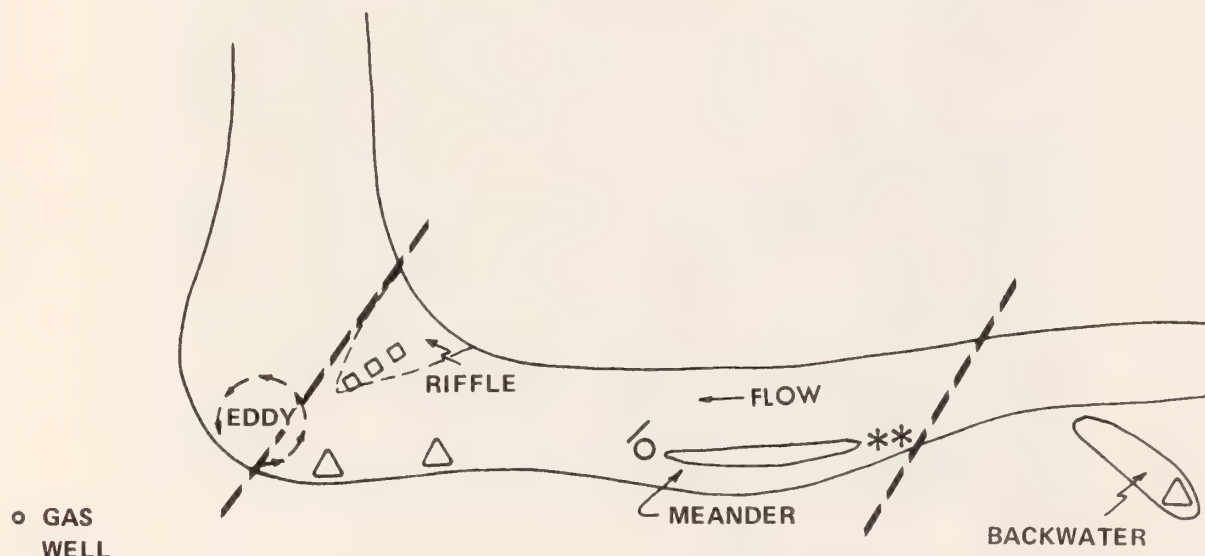


-  STATION LIMITS
-  PLANKTON SAMPLES
-  EKMAN SAMPLES
-  SURBER SAMPLES
-  HANDSCREEN SAMPLES
-  PERIPHYTON SAMPLER

STATION F-4 SHOWING VARIOUS SAMPLING LOCATIONS

FIGURE IV-31

F-5 (DIAGRAMMATIC)

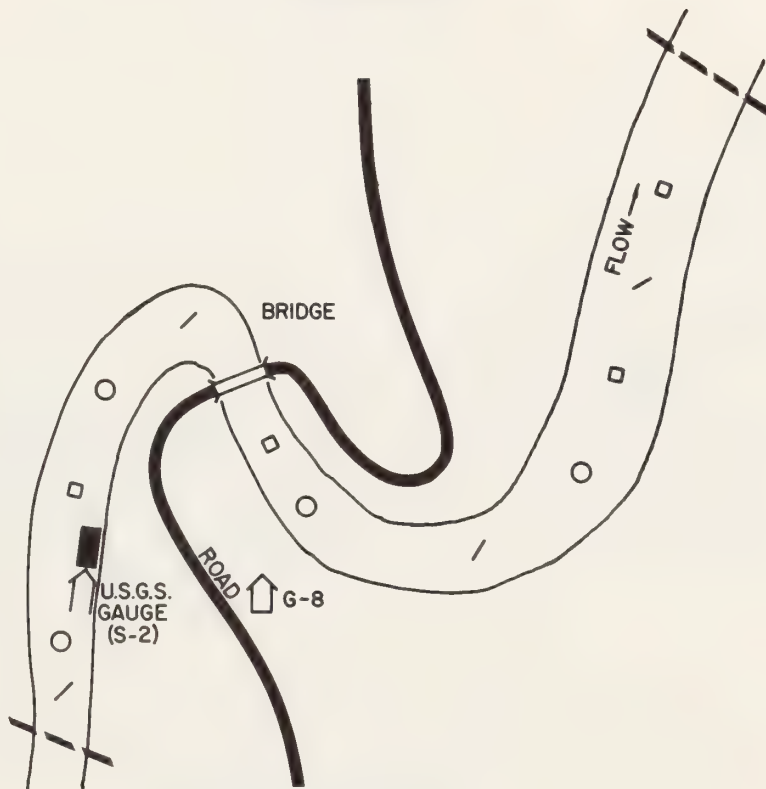


- STATION LIMITS
- PLANKTON SAMPLES
- * EKMAM SAMPLES
- SURBER SAMPLES
- / HANDSCREEN SAMPLES
- △ SEINE SAMPLES

STATION F-5 SHOWING VARIOUS SAMPLING LOCATIONS

FIGURE IV-32

F-6 (DIAGRAMMATIC)



- STATION LIMITS
- PLANKTON SAMPLES *
- SURBER SAMPLES *
- / HANDSCREEN SAMPLES *
- PERIPHYTON SAMPLER

*-OPPORTUNISTIC SAMPLING BECAUSE OF CHANGING STREAM CONFIGURATION

STATION F-6 SHOWING VARIOUS SAMPLING LOCATIONS

FIGURE IV-33



FIGURE IV-34 STATION F-1 MEANDER LOOKING DOWNSTREAM (SAMPLING SITE OUTLINED)



**FIGURE IV-35 STATION F-2, DOWNSTREAM VIEW FROM LEFT BANK
(SAMPLING SITE OUTLINED)**

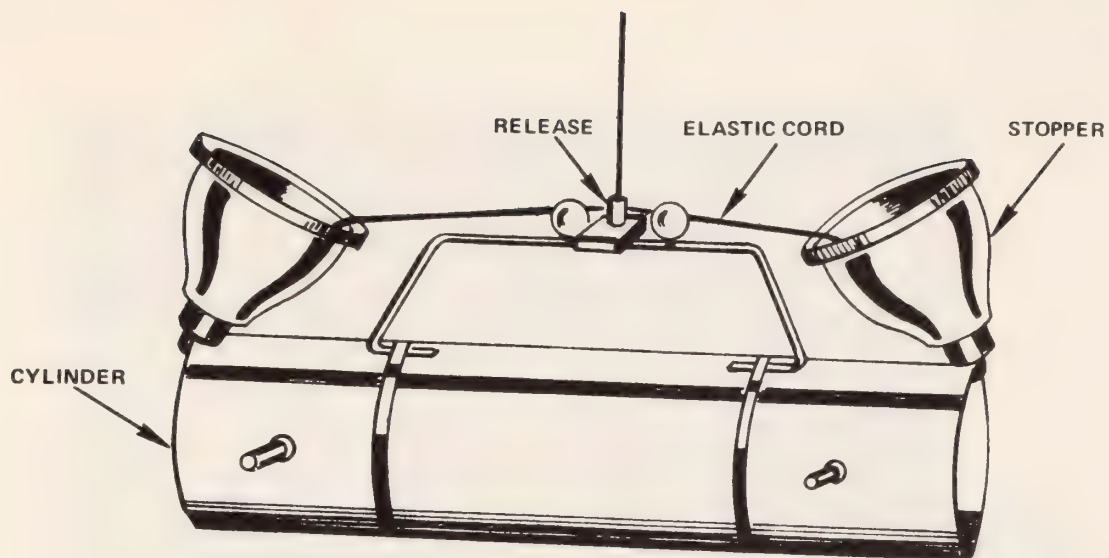
Exploration Plan. Some of the standard identification guides employed were Prescott (1970); Smith (1950); Patrick and Reimer (1966); and Weber (1971). A zeiss 32-x-1000x phase contrast microscope was used. Most samples were difficult to evaluate because they usually consisted mostly of sand and silt particles.

Alpha samples were concentrated by straining through a No. 16 mesh and washing into sample vials with a wash bottle (Figure IV-36). Aliquots from duplicate samples were placed in a Sedgewick Rafter counting cell and quantified in accordance with Section 601D, APHA 1971.

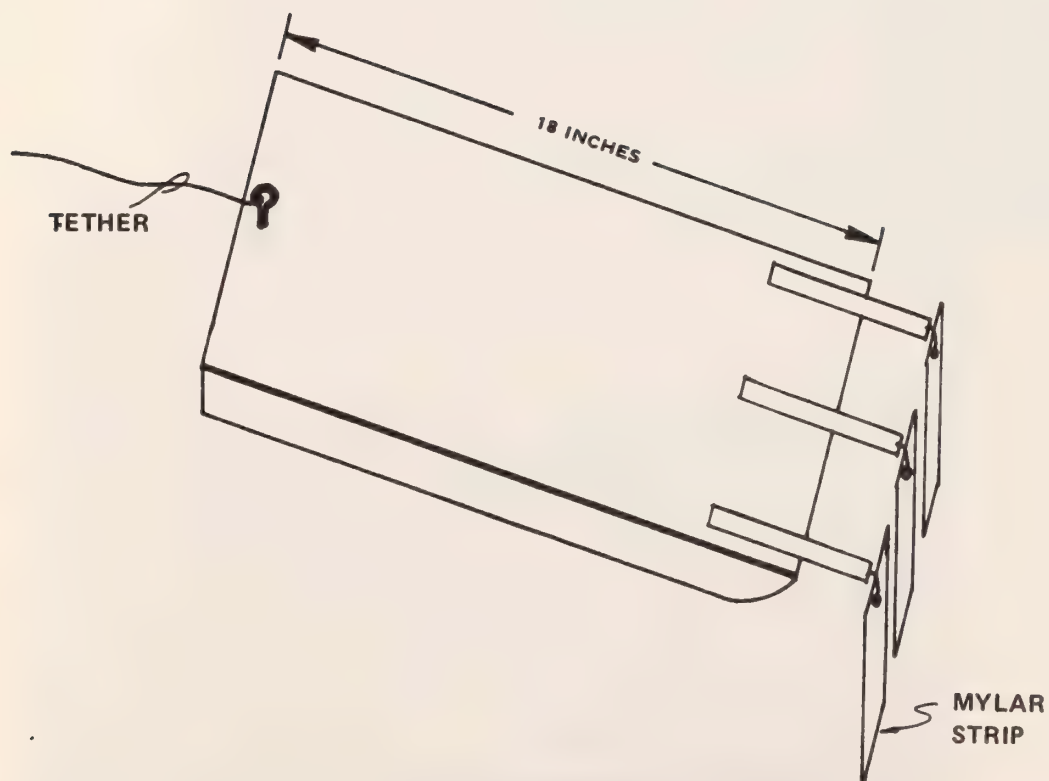
Periphyton samples were collected using 5.1-x-12.7-cm mylar substrates (Figure IV-36). The mylar strips were attached to floats or to the base of submerged turbidimeter probes. Samples were also scraped from submerged stones and vegetative debris. Samples were frozen and shipped to a USGS laboratory for analysis. The results were reported in standard USGS format and included biomass in grams per square meter (g/m^2); biomass-to-pigment ratio; and chlorophyll a and b, each in mg/m^2 . One sample strip preserved in formalin was used to identify specimens.

Aquatic invertebrates were sampled with a Surber sampler, an Ekman dredge, and a kickscreen, which is a piece of household window screen attached to handles. Invertebrates were also collected by handpicking and other qualitative methods. The Surber sampler was used to collect immature insects and other benthic invertebrates that live on submerged stones in shallow riffles (see figures IV-37 through IV-40). The sampler was placed against the substrate, and the material within the 1-sq-ft (0.093-m^2) frame was agitated vigorously. Dislodged organisms were caught in the net. An Ekman dredge was used to sample silty or soft-bottomed areas (Figure IV-40). Dredge material was cleaned in a wash bucket fitted with No. 30 screen. A kickscreen, a piece of screen approximately 1 m^2 with wooden handles attached to opposing sides, was used to sample areas too deep and swift for the other devices. The screen was placed against the bottom with the handles $\pm 0.6\text{m}$ apart, and the bottom was vigorously disturbed on the upstream side of the screen.

Samples taken by all the above methods were stored in formalin. Organisms were separated from debris with a dissecting microscope and were identified to the lowest practical taxon, usually genus or species, with the aid of microscopes and standard identification manuals: Usinger (1971); Pennak (1953); Edmundson (1959); etc. The identification of many of the taxa required use of papers from specialized scientific journals. Most taxonomic diagnoses were confirmed by other workers. Dr. Richard Bauman of Brigham Young University and Evan Horing of EPA, Las Vegas, were particularly cooperative in this



ALPHA TYPE OF WATER SAMPLER



FLOATING PERIPHYTON SAMPLERS

TYPES OF PERIPHYTON SAMPLERS

FIGURE IV-36



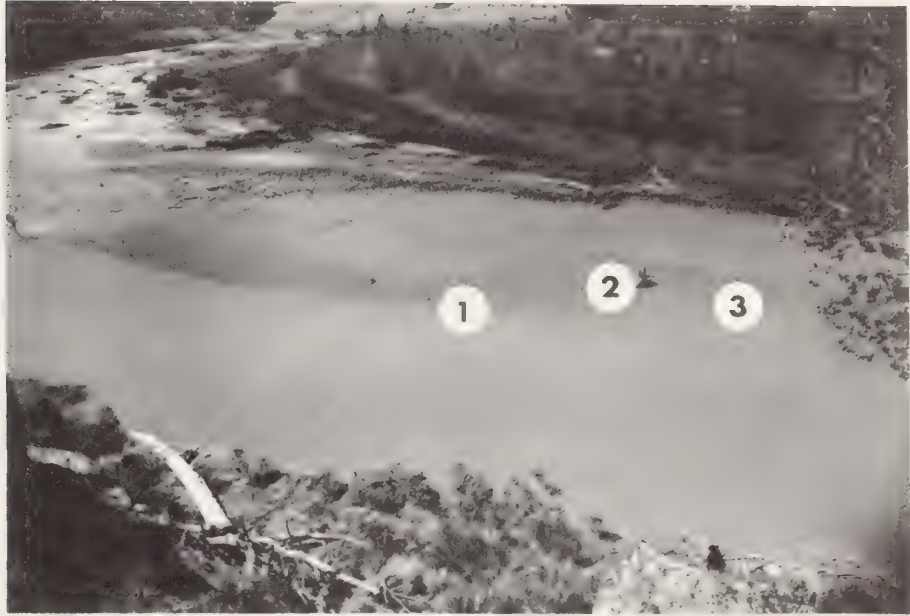


FIGURE IV-37

**RIFFLE DOWNSTREAM OF F-4
(NUMBERS SHOW LOCATION OF SURBER SAMPLES)**



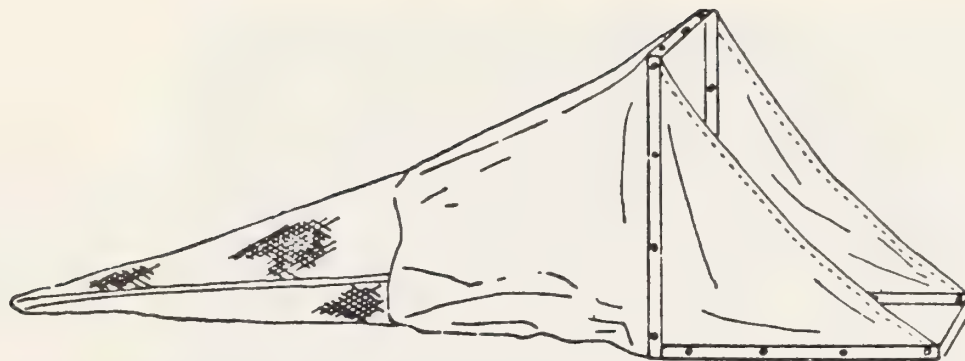
FIGURE IV-38

STATION F-4 (NUMBERS SHOW LOCATION OF SURBER SAMPLES)

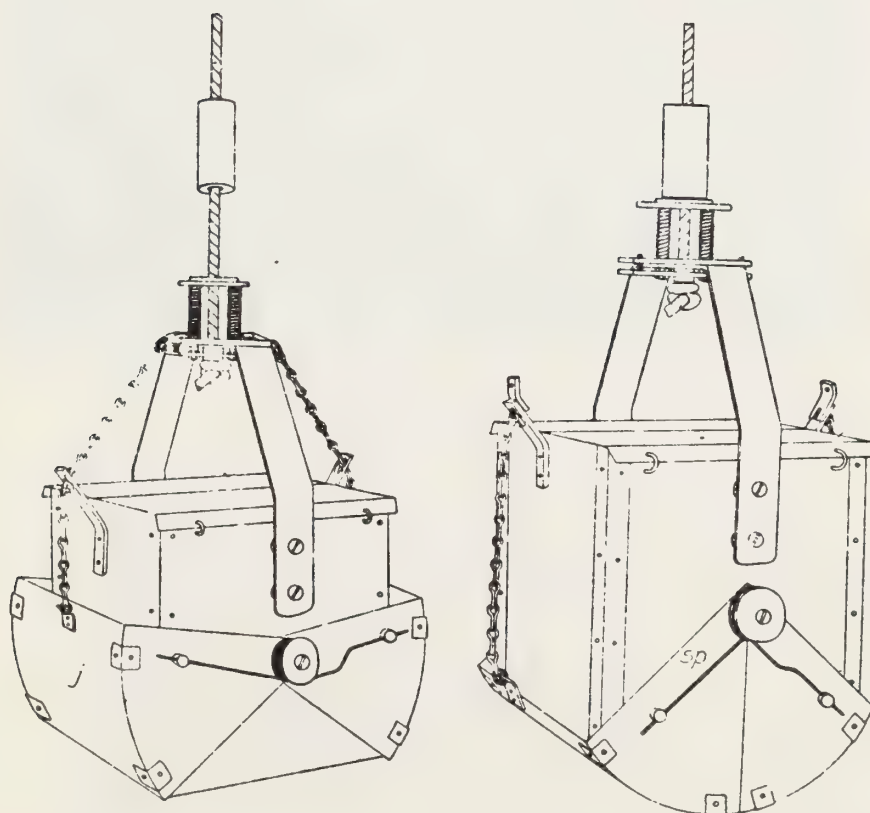


FIGURE IV-39

STATION F-5 (NUMBERS SHOW LOCATION OF SURBER SAMPLES)



SURBER SAMPLER
SOURCE: U.S.P.H.S., 1971



DREDGE-OPEN (LEFT) AND CLOSED
SOURCE: WELCH, 1948.

TYPES OF MACROINVERTEBRATE SAMPLERS

FIGURE IV-40



respect. Specimens from the samples were counted, species diversity (Shannon-Weaver) was calculated, and population densities were described using basic statistics.

The fishery was sampled by the Utah Division of Wildlife Resources at eight stations from Hells Hole Canyon to the Green River confluence near Ouray, Utah. Samples were taken by VTN in the lease areas using minnow traps, seines, and other methods permitted by the Utah Aquatic Wildlife Proclamation. A scientific collection permit was not available to VTN investigators. The DWR collected fish with a 220-volt D. C. electrofisher. The DWR samples were forwarded to BYU for use in a study by that school (Bauman et al. 1975).

2. SUMMARY OF RESULTS

a. Habitat

The permanent aquatic habitat on the lease areas consists of the White River and a tributary, Evacuation Creek. The White River is a tributary of the Green River in the Upper Colorado River basin and drains approximately 11,000 km² (4,000 sq mi) above the lease areas. The river has a base flow of about 10 m³/s (350 cfs) from August through March, and when snowmelt causes runoff discharge exceeds 57 m³/s (2,000 cfs). In the lease areas, the stream averages approximately 30 m (100 ft) wide and 0.6 m (2 ft) deep at the baseflow. Hydrology is discussed in Section II. Pool-to-riffle ratio is near one, with pools reaching to nearly 2 m deep.

Habitat conditions in the lease area streams are discussed in the First Year Environmental Baseline Report (FYEBR). Nothing additional was discovered during the second year; however, one notable event affecting substrate did occur in March 1976. The bottom structure at Station F-3 (see Figure IV-30) is normally composed mostly of shale rubble and cobble (stone approximately fist sized) and small boulders. On March 16 the station was visited for sampling and found to consist of 100% fine sand. Hydrologists related that an ice jam had occurred at the bend approximately 150 m downstream of the bridge. The ice jam had apparently created a dam that caused an abrupt reduction in current velocity, causing much of the suspended material to fall to the bottom in the reduced current. As a result the station was nearly devoid of benthic invertebrates, except on stones, which were densely populated. When the suspended material began to cover the bottom, most invertebrates apparently either released their hold on the substrate and left the area or were covered by sand.

b. Aquatic Macrophytes

There are virtually no aquatic macrophytes in streams of the lease area, as described in the FYEBR; their absence made sampling impossible. *Phragmites communis* and other riparian plants are discussed in Section IV.A.

c. Periphyton

"Periphyton" is defined as a community of filamentous and unicellular algae, protozoans, rotifers, bacteria, fungus, and other small organisms that live in close association with the surface of submerged stones and other objects. Periphyton algae are the primary producers of biomass and chlorophyll in streams such as the White River and Evacuation Creek.

The periphyton sampling program was not as successful as originally hoped because of a variety of problems such as the physical stream characteristic of the White River and other influences, which are discussed in the FYEBR. During the second year many of these problems were overcome, but others arose. For instance, the samplers must remain in the water for approximately four weeks for sufficient algal growth to accumulate, and the samplers must float near mid-stream to avoid excessive shade or to avoid stranding as the river stage decreases. In this position they are subject to disturbance by visitors to the area. Several samples that were collected were held up during shipment to the USGS laboratory and were spoiled.

Data from usable second year samples are shown on Table IV-69. The data are consistent with those found in the San Juan River, New Mexico, a similar stream. The San Juan River data are given on Table IV-70 for comparison. The sampling methodology was the same.

There are two distinct periphyton communities in the White River. One occurs on submerged objects in shallow water and is composed mainly of the green algae *Cladophora glomerata* and the diatoms *Cocconeis placentula*, *Gomphonema olivaceum*, and *Synedra acus*, as well as many less abundant species. The composition of the flora varies with temperature, season, rate of discharge, and other factors. The diatom *Cocconeis placentula* occurs mostly as an epiphyte on green algae *Cladophora glomerata*. When the green algae *Cladophora* is reduced by a flood or other event, diatoms *Cocconeis* becomes less abundant. Diatoms *Gomphonema olivaceum* and *S. acus* are common to abundant throughout the year.

TABLE IV-69

U.S.G.S. PERIPHYTON ANALYSES

<u>Date</u>	<u>Parameter</u>	<u>F-1</u>	<u>F-3</u>	<u>F-4</u>	<u>F-5</u>	<u>F-6</u>
Nov 75	Biomass (ash) G/m ²		0.1	0.0	24	4.3
	Biomass (dry) G/m ²		0.4	0.0	24	4.5
	Biomass:pigment ratio		1400	0.0	680	93
	Chlorophyll a Mg/m ²		0.2	0.0	0.7	1.7
	Chlorophyll b Mg/m ²		0.0	0.0	0.0	0.1
Apr 76	Biomass (ash) G/m ²	252	22.9	2.31		1.54
	Biomass (dry) G/m ²	268	27.2	2.85		1.92
	Biomass:pigment ratio	420	570	550		0.0
	Chlorophyll a Mg/m ²	37.1	7.56	.98		0.00
	Chlorophyll b Mg/m ²		0.00	0.00		0.00
July 76	Biomass (ash) G/m ²		* 4.61	** 3.83		
	Biomass (dry) G/m ²		5.00	4.53		
	Biomass:pigment ratio		.4	0.45		
	Chlorophyll a Mg/m ²		1.02	1.56		
	Chlorophyll b Mg/m ²		0.29	0.31		
Aug 76	Biomass (ash) G/m ²	2.87	6080			
	Biomass (dry) G/m ²	3.62	7540			
	Biomass:pigment ratio	12.9	18480			
	Chlorophyll a Mg/m ²	.05	.08			
	Chlorophyll b Mg/m ²	.02	.03			
Sept 76	Biomass (ash) G/m ²		6.32			
	Biomass (dry) G/m ²		** 8.05			
	Biomass:pigment ratio		.7			
	Chlorophyll a Mg/m ²		2.61			
	Chlorophyll b Mg/m ²		0.55			
	Standing Crop					

* Bottom periphyton sample (30-day)

** Bottom periphyton standing crop

TABLE IV-70

SAN JUAN RIVER PERIPHYTON

Date	Length of Exposure (days)	Biomass (g/m ²)		Biomass Pigment Ratio	Chlorophyll ^a (mg/m ²)	Chlorophyll ^b (mg/m ²)
		Ash Weight	Dry Weight			
Dec. 18, 1974	27	3.1	3.8	170	4.1	0.7
April 10, 1975	29	0.2	0.6	--	0.0	0.0
May 7, 1975	27	0.5	1.4	15,000	0.1	0.0
Aug. 14, 1975	36	6.9	8.8	--	21.0	2.2

Source: Water Resources Data for New Mexico, Water Year 1975.
U.S. Geological Survey Water Data Report NM-75-1.

The second community occurs on more deeply submerged stones and consists of mostly the bluegreen algae *Phormidium* sp. The prevailing light at depths of more than 25 cm to 30 cm (9 in. to 12 in.) is apparently inadequate to support abundant green algae or diatoms.

The periphyton of Evacuation Creek resembles that of shallow areas in the White River, but green algae *Cladophora glomerata* is replaced by several filamentous green algae. The algae *Spirogyra* spp. is the most abundant in Evacuation Creek, but the algae *Mougeotia*, *Oedogonium*, *Zygnema*, and *Ulothrix* spp. are seasonally abundant. Dominant diatom populations also shift seasonally, with *Achnanthes lanceolata*, *Cyclotella meneghiniana*, *Navicula cryptocephala*, and *Pleurosigma* sp. often becoming common to abundant. Table IV-71 lists the algae identified and their relative abundances (based on microscopic occurrences), which shift temporarily, as noted previously.

The most important regulators of algal productivity in the streams are fluctuating water levels and turbidity. Spates are particularly important in Evacuation Creek, with local storms producing high water levels and extreme turbidity. The stream soon returns to its usual trickle of approximately 7 l/sec (0.25 cfs), and the bottom structure is left devoid of algal growth. Within a few days, filamentous algae become apparent and diatoms are abundant.

The White River reacts less rapidly, but follows a similar chain of events. The second community mentioned in the White River (deeper areas) is less affected by scouring than are the shallow areas dominated by algae (*Cladophora glomerata*), and diatoms (*Cocconeis placentula*, *Syndera acus*). When discharge abates following a flood event, shallow areas quickly become populated with the green algae. When the rate of discharge remains low ($8.5 \text{ m}^3/\text{s}$ or 300^+ cfs) and fairly constant for an extended period, the periphyton grow rapidly, indicating an abundance of required nutrient materials in the water.

d. Plankton

During the baseline period, plankton populations fluctuated from near zero to about 110/ml in the White River, and from near zero to 150/ml in Evacuation Creek. These numbers are very low in comparison to typical river systems, partly because of environmental conditions in the streams, as discussed in the FYEBR and in Section IV.D.4. Few animals were found in the plankton, except for protozoans, which were abundant infrequently. Nearly all phytoplankton consist of diatoms that normally occur as periphyton. The average number of

TABLE IV-71

ALGAE

<u>Genus</u>	<u>White River</u>	<u>Evacuation Creek</u>
<i>Achnanthes lanceolata</i>	C	A
<i>A. linearis</i>	C	R
<i>Amphiprora palludosa</i>	I	C
<i>A. ornata</i>		I
<i>Amphora coffeaeformis</i>	R	
<i>A. ovalis</i>	I	I
<i>Cocconeis placentula</i>	A	C
var <i>lineata</i>		
<i>Cyclotella meneghiniana</i>	I	A
<i>Cylindrotheca gracilis</i>		C
<i>Cymbella mulleri</i>		I
<i>Cymbella</i> spp.	C	C
<i>Diatoma hiemale</i>	A	C
<i>D. vulgare</i>	C	I
<i>Epithemia sorex</i>	I	I
<i>Fragillaria</i> spp.	C	C
<i>Gomphonema olivaceum</i>	A	C
<i>Gyrosigma</i> sp.	R	C
<i>Mastigloia</i> sp.	C	I
<i>Navicula cryptocephala</i>	C	A
<i>N. radiosa</i>	I	C
<i>N. tripunctata</i>	C	C
<i>N. zannoni</i>	I	I
<i>Navicula</i> spp.	C	C
<i>Nitzschia tryblionella</i>	I	C
<i>Nitzschia</i> spp.	C	C
<i>Pinnularia</i> sp.	I	C
<i>Pleurosigma</i> sp.	I	A
<i>Rhopalodia gibba</i>	I	C
<i>R. gibberula</i>	R	I
<i>Surirella ovata</i>	I	I
<i>S. ovalis</i>	C	I
<i>Synedra acus</i>	A	A
<i>S. ulna</i>	I	I
<i>Synedra</i> sp.	C	C

Filamentous or Unicellular Cyanophyta, Chlorophyta, and Chrysophyta

<i>Cladophora glomerata</i>	A	C
<i>Cladophora</i> sp.	R	
<i>Mougeotia</i> sp.		A
<i>Oedogonium</i> sp.		A
<i>Spirogyra</i> spp.	R	A
<i>Ulothrix</i> sp.	R	C
<i>Zygnema</i> sp.	R	A
<i>Vaucheria</i> sp.	R	
<i>Avabena</i> sp.	I	C
<i>Aphanothece</i> sp.		R
<i>Chroococcus</i> sp.	C	C
<i>Lyngbya</i> sp.	I	C
<i>Oscillatoria</i> sp.	C	A
<i>Phormidium</i> sp.	A	C
<i>Rivularia</i> sp.	C	I
<i>Spirulina</i> sp.	A	I
<i>Synecocystis</i> sp.		C

A=Abundant C=Common I=Infrequent R=Rare

cells per liter for four major samplings for the two-year period are shown on tables IV-72 and IV-73.

Most of the algae occurring as plankton are periphyton organisms that have been dislodged by the current, and therefore the composition of the plankton is similar to that of the periphyton listed on Table IV-71.

e. Macroinvertebrates

The White River supports a benthic macroinvertebrate fauna that is typical of medium-sized rivers in the intermountain area. Evacuation Creek flows intermittently, and the fauna is mostly restricted to insects that mature rapidly or are quite mobile. Approximately 85 invertebrate genera were collected from the White River, but Evacuation Creek produced only a few species of hemipterans (*Gerris* sp.), beetles (*Hydroporus* sp., *Agabus* sp.), and dipterans of the families Chironomidae and Simuliidae. A short portion of Evacuation Creek that usually contains some water flows through an aquifer in the vicinity of the Highway 45 bridge. Mayflies (*Baetis* sp.) and limnephilid caddis larvae may occasionally be found in this section. The FYEBR lists the invertebrates collected during the first year of the baseline study (Figure IV-41). The following additional species were captured during the second year:

Capnia vernalis (stonefly)

Taenionema pacifica (stonefly)

Brachycercus (prudens) (mayfly)

Leptohyphes sp. (mayfly)

Illinobdella moorei (leech)

The caddis fly referenced as *Cheumatopsyche* sp. in earlier reports was determined to be *Hydropsyche* sp., now listed as sp. A and sp. B.

The seasonal effects on aquatic populations were discussed previously and in the FYEBR. Surber sample yields ranged from an average of 13.4 to 317 per 0.093 m² during major spring and autumn sampling. Data are summarized on Table IV-74. In general, macroinvertebrate populations were noticeably more dense in autumn than in spring. Spring populations were less dense than those of autumn because invertebrates that grow and mature during winter (mostly stoneflies) had emerged by then and many of the summer-maturing mayflies and dipterans were too small for capture with the methodology used. More

TABLE IV-72

PHYTOPLANKTON COUNTS - WHITE RIVER
(cells per liter)

<u>Date</u>	Station Number					
	<u>1</u>	<u>2</u>	<u>3</u>	<u>4</u>	<u>5</u>	<u>6</u>
April 1975	9,700	9,400	4,800	22,200	12,300	a.
September 1975	63,000	87,000	111,000	51,400	79,000	143,000
March 1976	32,000	37,000	24,000	b.	14,000	3,700
August 1976	19,000	32,000	19,000	c.	25,000	d.

- a. Stream frozen
 b. Station inaccessible
 c. Sample accidentally destroyed
 d. Too few to count

TABLE IV-73

PHYTOPLANKTON STATISTICAL DATA - WHITE RIVER

<u>Date</u>	Number of Samples	Sum of Samples	Mean	Standard Deviation	Variance	Standard Error	90% Confidence Level About Mean
	<u>n</u>		<u>$\bar{x}$</u>	<u>s</u>	<u>s^2</u>	<u>$S\bar{x}$</u>	<u>$x^+ (t) (S\bar{x})$</u>
April 1975	5	58	11.7	6.5	42.2	2.9	11.7 ⁺ 4.4
September 1975	5	391	78.3	22.7	515.3	10.2	78.3 ⁺ 15.5
March 1976	4	107	26.7	10.0	100.0	5.0	26.7 ⁺ 7.7
August 1976	4	70	23.3	7.5	56.2	3.8	23.3 ⁺ 5.7

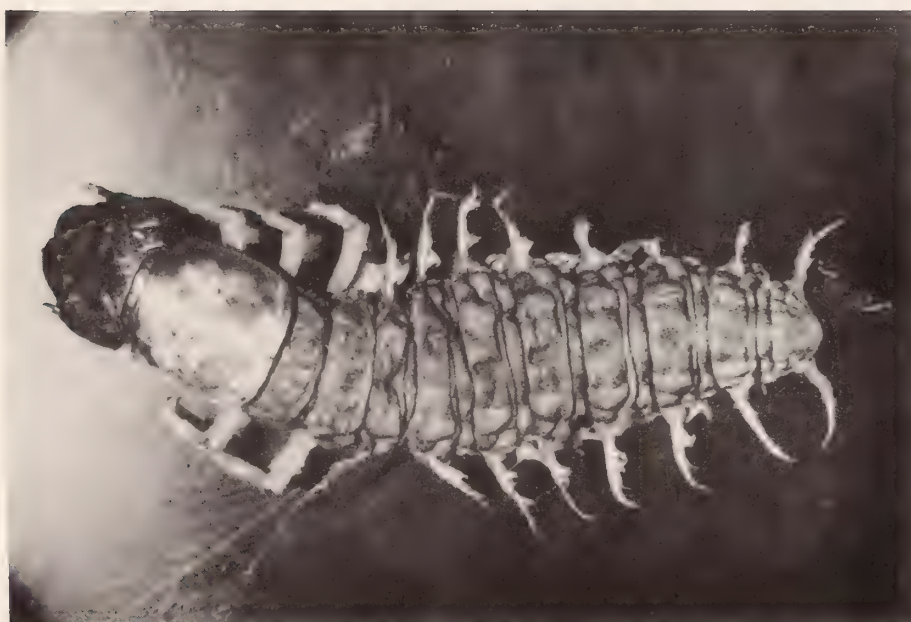


FIGURE IV-41 CORYDALUS SP., A LARGE DOBSONFLY LARVA (APPROXIMATELY 1.3X).
RARE IN WHITE RIVER.

TABLE IV-74
SURBER SAMPLE DATA SUMMARY-
WHITE RIVER

Sample Date	April 1975	September 1975	March 1976	August 1976
F-1				
N*	17	153	111	242
$\bar{d}^{**}$	3.10	2.93	2.93	1.03
Y***	9	18	20	21
No. of Samples	2	5	5	5
F-2				
N	8	185	9	567
$\bar{d}$	3.17	3.25	3.37	0.44
Y	11	20	14	15
No. of Samples	5	5	5	5
F-3				
N	25	163	74	105
$\bar{d}$	3.34	2.79	2.96	1.72
Y	17	20	22	21
No. of Samples	4	5	5	5
F-4				
N	13	80	14	97
$\bar{d}$	2.94	2.70	2.46	1.78
Y	10	18	14	16
No. of Samples	5	5	5	5
F-5				
N	4	144	22	220
$\bar{d}$	2.46	2.03	3.60	1.58
Y	9	17	16	22
No. of Samples	3	5	5	5
Averages				
N 19	13	145	46	246
$\bar{d}$	3.00	2.74	2.74	3.00
Y	11	17	17	19

* Average number organisms/sample

** Composite Shannon Weaver diversity index--5 samples

*** Total number of taxa per 5 sample composite.

invertebrates were captured per unit area in 1976 than in 1975. There was no documented reason for the increased density in 1976, but it could be hypothesized that more eggs and early instars survived because of reduced spring runoff intensity.

There was also a marked annual change in the fauna during late August and early September with the emergence of the mayflies (*Traverella albertana* and *Lachlania saskatchewanensis*). These large mayflies, which appeared in benthic samples in June or July of each year, grew rapidly until they matured and emerged during the first weeks of September. *L. saskatchewanensis* were the most abundant in the vegetative debris that accumulates on snags in mid-channel, and therefore only a few appeared in Surber samples. Because of the emergence, samples taken in August or early September contain far more organisms than do those taken in late September. Tables IV-75 and IV-76 show this difference.

Collection of the samples on tables IV-75 and IV-76 was begun on September 26, 1975, and August 10, 1976, respectively. Samples taken by Baumann et al. (1975) in July and August 1975 reflected much higher densities than those taken by VTN a few weeks later. The Environmental Protection Agency sampled similar areas in October 1975 and found densities corresponding to those in the VTN sampling (Hornig 1976). Densities increased somewhat in late autumn, as stoneflies appeared in samples; but population densities were always highest in late summer.

Three kinds of sampling methods were used to sample macro-invertebrates--the Surber sampler, Eckman dredge, and kick-screen. The method used depended on the type of substrate being sampled, so the habitat for each type of sample was similar at all stations. Surber samplers were used to sample areas with rocky bottoms. The diversity indices in Surber samples from the White River were usually near 3.0 unless one taxon was particularly abundant. Table IV-77 shows Shannon-Weaver diversity data for the August 1976 Surber samples, shown on Table IV-76. Table IV-74 shows diversity and other data for major Surber samplings of the two-year baseline period. In August 1976 *Traverella albertana* were extremely abundant in the shallow water at Surber sampling sites, apparently in preparation for emergence. Tables IV-74, IV-76, and IV-77 show the effects of this on diversity indices. Diversity indices ranged from 0 to 3.60 and averaged 1.97 for approximately 100 samples. About 20% of the samples were in the 3.0 to 4.0 range that Wilhm (1970) found typical of "clean" waters, and about 65% were above 2.0. This compares favorably with USGS information for ecologically similar rivers (Lium 1976). These tables are examples of lumped data. Wilhm (1970) showed that the indices increase as samples are pooled. After pooling five to eight samples, an asymptotic level is

TABLE IV-75
MACROINVERTEBRATE DATA; WHITE RIVER, UTAH; SURBER SAMPLES, SEPTEMBER 1975

	F-1					F-2					F-3					F-4					F-5					TOTAL						
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	TOTAL	
EPHEMEROPTERA																																
<i>Hesperia elegans</i>	19	52	19	44	21	42	6	39	23	68	21	42	22	20	17	2	2	5	61	59	6	11	104	54	21	789						
<i>Rhyacophila angulata</i>	8	8	3	14	22	24	34	8	12	4	7	9	29	1	46						1	1	3	7	7	268						
<i>Bella</i> sp. A	3	2		3	6	2	2	3	4	4					1					2						32						
<i>Bella</i> sp. B	6	3		3	4	2	2	4	4	5	2	4								1	5	4				18						
<i>Deutylabus capensis</i>	24	6	1	7	9	70	35	21	20	19	19	23	38	27	32	1		1	5	4	2	3	6	22	9	473						
<i>Pseudocricotopus turbidus</i>						1												2	42	29						45						
<i>Lachania ussatchewensis</i>	9	33	10	122	136	5	18	11	49	68	28	45	76	30	74	16	5	13	23	46	12	6	65	224	83	1,187						
<i>Traverella alberrans</i>						1					1									6						17						
<i>Chironomus albicollis</i>	17	11	9	21		7	4	7	3	17	1	6	3	3		13				2	1	1	2	7		118						
<i>Ephemerella (nervis?)</i>						4					4	4	3	2	1					2				8	3	48						
<i>Trichopterus minutus</i> (?)				2	1															2						3						
<i>Trichopterus edmundi</i> (?)	1					4		5												2						13						
COONATA																																
<i>Opilognathus arvensis</i>	1		2	4		2	2	2		2		1				2	4				2	1	3	2		31						
<i>Helicaria</i> sp.																1										1						
PLECOPTERA																																
<i>Isogenodes frontalis</i>	2		2	12		3	1				2		5	1	1	1					5	4	3			43						
TRICHOPTERA																																
<i>Hydropsyche</i> sp.	4	5	4	3	19	66	5	9	74	54	10	4	56	14	34	1				7	2	5	7	7	1	391						
<i>Blachycrinus</i> sp.																				5	3	6	1	1		1						
<i>Leptoclella</i> sp.													1													16						
DIPTERA																																
<i>Chironomus</i>	2	1	2	4	9	2	3	5	6	1	1	2	4							2	2	1	2			46						
<i>Chironomus</i> sp.																										6						
<i>Orthocladus</i> sp.																										6						
<i>Cricotopus</i> sp.																				3						4						
<i>Hesione</i> sp. (Tipulidae)																				2						2						
<i>Ephyridae</i>																										3						
<i>Ceratopogonidae</i>																										1						
<i>Empididae</i>																										1						
<i>Simuliidae</i>	1			6	2															3		1				39						
PLESIPODIA (Annelida)																																
<i>Limnodynus clarendonensis</i>																											7					
<i>Naididae</i>																				1	2					7						
NEMATODA																																
																											1					
per ft ²	87	125	38	225	277	228	118	115	208	255	85	113	260	114	217	38	16	32	149	164	34	44	195	340	106	3,524						
per m ²	1,044	1,345	420	2,421	2,981	2,453	1,270	1,237	2,238	2,744	1,022	1,216	2,787	1,227	2,336	408	172	254	1,603	1,765	366	473	2,098	3,658	1,141							

TABLE IV-78

••• Formerly referred to Chomatopsyches sp

TABLE IV-77

SPECIES DIVERSITY (d) INDICES OF BENTHIC INVERTEBRATES
BY SHANNON WEAVER FUNCTION
WHITE RIVER UTAH, AUGUST 1976 SURBER SAMPLES

<u>Station</u>	<u>Sample No.</u>	<u>SDI*</u>	<u>N**</u>	<u>Y***</u>
F-1	1	2.33	63	11
	2	0.17	284	3
	3	0.71	108	8
	4	1.54	29	4
	5	0.35	726	9
	Composite	1.03	1210	21
F-2	1	0.80	212	8
	2	0.55	176	7
	3	0.83	130	6
	4	0.44	867	10
	5	0.27	1449	8
	Composite	0.44	283	15
F-3	1	0.78	50	4
	2	2.59	56	11
	3	2.37	68	11
	4	1.02	262	12
	5	1.80	91	8
	Composite	1.72	527	21
F-4	1	1.36	52	7
	2	1.11	100	11
	3	0.92	27	3
	4	1.52	113	11
	5	2.21	187	13
	Composite	1.78	479	16
F-5	1	2.31	134	12
	2	0.82	291	11
	3	0.55	318	9
	4	1.86	180	12
	5	2.04	179	12
	Composite	1.58	1102	22
	Average individual sample	1.23	246	9

* Species Diversity Index (Shannon-Weaver)

** Number of invertebrates per ft² (0.093m²)

*** Number of taxa per sample

reached that more clearly reflects actual conditions. Some statistical data derived from Surber sampling are shown on Table IV-78.

The Ekman dredge was used to sample organisms that dwell in, or burrow into, silted areas. The predominant organisms for most streams in such areas are ceratopogonid, or chironomid larvae, and tubificid worms. The White River was typical in this respect. Densities ranged from a low of approximately 2 organisms per 1/4 sq ft in September 1975 to 65 in November 1974. The two largest individual 1/4-sq-ft-samples contained 128 and 194 organisms.

Table IV-79 shows data from the August 1976 Ekman dredge samples. The composition of the population varied considerably according to the nature of substrate, which was either loamy or sandy and contained varying amounts of detritus. The density of organisms was generally low, indicating that oxygen levels and other conditions on the bottom do not provide the conditions that are usually necessary for large numbers of worms and dipteran larvae per unit area. The genera and numbers shown are representative of those found during the study. As with other populations, those sampled with the Ekman dredge were clumped and produced data with low confidence levels. For example, the August 1976 samples ranged from 14 to 349 organisms. Standard deviation (S) was 139, and standard error of the mean (Sx) was 46.

Kickscreens were used to sample communities similar to those suited for Surber Sampling but in fast currents in deeper water. Because the screen apertures are large, many macro-invertebrates passed through, and therefore the apparent densities were lower than those of the Surber samples.

f. Fisheries

Prior to this study, fisheries data for the White River were practically nonexistent. This is due in part to the fact that there is no significant sport fishery to generate interest, and partly because the river is difficult to sample. Olsen (1973) recounts these difficulties:

On four separate occasions, from October 26 through November 23, efforts were made to collect fish through the use of electro-fishing equipment, rotenone and explosives. Only four fish resulted from these efforts, three flannel-mouth suckers and one speckled dace.

TABLE IV-78
SURBER DATA - WHITE RIVER
(Major Samplings)

	<u>April 1975</u>	<u>Sept 1975</u>	<u>March 1976</u>	<u>Aug 1976</u>
Number of Samples (n)	19	25	25	25
Total Captures	254	3624	1145	6152
Mean ($\bar{x}$)	13.4	145	46	246
Standard Deviation (S)	11.5	89	50	314
Variance (S^2)	132	7921	2500	98596
Standard Error ($S\bar{x}$)	2.6	18	10	63
90% Confidence Limit About Mean ($\bar{x} \pm (t)(S\bar{x})$)	13.4 $\pm$ 3.5	145 $\pm$ 24	46 $\pm$ 13	246 $\pm$ 83

NOTE:

Overall average diversity indices (SDI) and number of organisms per capture (N) are as follows:

<u>Station</u>	<u>SDI</u>	<u>N</u>
1	1.58	105
2	1.78	56
3	2.41	83
4	1.85	45
5	1.96	46

Statistical comparisons between stations are not appropriate because of varying depth, current velocities, and other physical conditions of the White River.

TABLE IV-79

EKMAN DREDGE DATA, AUGUST 1976
WHITE RIVER

Data shown are composites of 10 samples at each station

Station	1	2	3	4	5
Ephemeroptera					
<i>Heptagenia elegantula</i>			1		7
<i>Traverella albertana</i>			2		
<i>Tricorythodes sp.</i>					21
Odonata					
<i>Ophiogomphus severus</i>	2	1	19	7	17
Diptera					
Tipulidae					
<i>Hexatoma sp.</i>					9
Ceratopogonidae		3	9	4	
Chironomidae					
<i>Sp. A</i>	12	32	16	23	201
<i>Sp. B</i>			9		
Annelida					
<i>Limnodrilus claparedianus</i>		6	22	2	94
Total	14	42	78	36	349
Average No./m ²	60	174	336	155	1502
Average No./ft ²	6	17	31	14	140

The Utah DWR sampled eight stations from Hells Hole Canyon to the Green River in 1974 and 1975 using a 220-volt shocker. The results, which were better than those of previous studies, are discussed in the FYEBR. By way of review, in 1974, 1313 fishes of nine species were captured, and within the lease area, 304 specimens of seven species were captured (FYEBR). The most abundant species captured were the flannel-mouth sucker, (*Catostomus latipinnis*), speckled dace (*Rhinichthys osculus*), fathead minnow (*Pimephales promelas*), and red shiner (*Notropis lutrensis*). In 1975 the DWR used similar techniques and captured 365 specimens representing 10 species. Within the lease area, seven species accounted for 155 specimens. Only one fathead minnow was taken compared to 64 in 1974.

The Utah DWR did not sample the river in 1976, and VTN could not sample without a collecting permit. Sampling was limited to areas suitable for seining or to riffles that could be worked with a kickscreen. Sampling was conducted at stations F-2 and F-3 using a 6.1-m (20-ft) sein with $\pm$ 6-mm 1/4 in.) bar mesh, and a kickscreen normally used for sampling invertebrates. The kickscreen was very effective for catching speckled dace in the shallow riffles where they are the most common. Roundtail chubs (*Gila robusta*) of 25 cm (10 in.) were captured with the screen in the meander below Bonanza Bridge (Figure IV-42 and IV-43). A pool in this meander usually contained several of the chubs.

The limited capture-recapture data (i.e., the data are too few to be reliable indicators of population densities) from the DWR are shown on Tables IV-80 and IV-81. Table IV-81 also lists the additional species reported in the FYEBR. In addition to these fishes, seven channel catfish were captured by angling. Some of these specimens were as long as 43 cm (17 in.), and several were infested with 25 or more leeches (*Illinobdella moorei*). The leeches were found only in August 1976 and were not found on any of the 2000 $\pm$ fish specimens collected at other times.

Additional species collected by the DWR include fathead minnow; smallmouth bass (*Micropterus dolomieu*); and brown trout (*Salmo trutta*). The bass and trout were captured near the confluence of the Green River from which they probably wandered. Pettus (1974) reported from the White River in Colorado mottled sculpin (*Cottus bairdi*) and the mountain whitefish (*Prosopium williamsoni*).

Several endangered or potentially threatened fish species could occur in the White River. They are the Colorado squawfish (*Ptychocheilus lucius*) and the humpback chub (*Gila cypha*), both endangered (Federal Register 1976), and the bony tail chub (*Gila elegans*) and humpback sucker (*Xyrauchen taxanus*). The last two are not listed as endangered, but they are certainly not common. None of these four species were collected during



FIGURE IV-42
RIFFLE AT STATION F-2

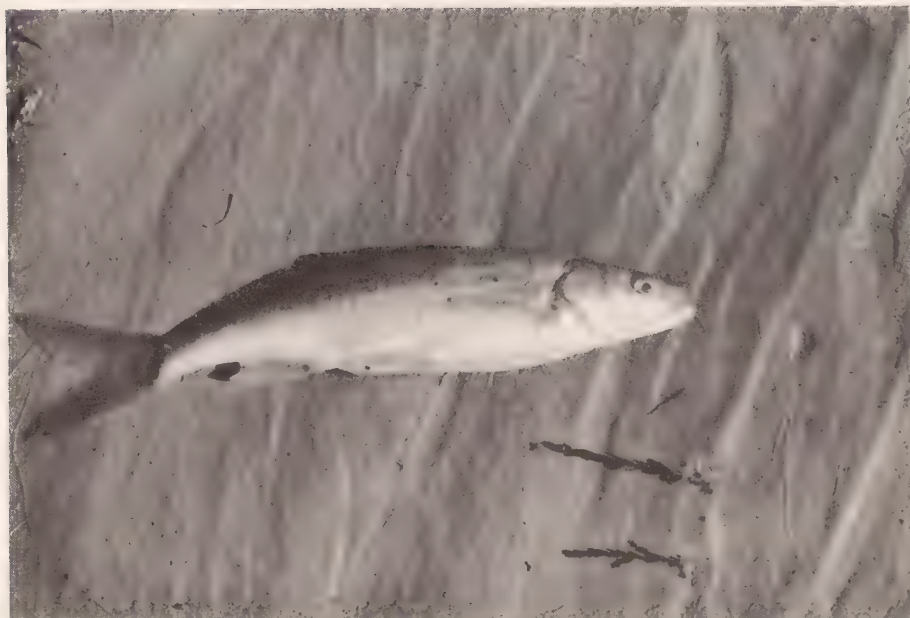


FIGURE IV-43
ROUND-TAIL CHUB

TABLE IV-80
FISHERY CAPTURE - RECAPTURE DATA

<u>Station</u>	<u>Day 1</u>		<u>Day 2</u>	
F-2 (Aug. 76)	Captures	60	Captures	75
	Mortality	3	Marked	2
	Population*= 2,137			
F-3 (Aug. 76)	Captures	73	Captures	105
	Mortality	15	Marked	19
	Population*= 343			
F-3 (Sep. 76)	Captures	215	Captures	166
	Mortality	21	Marked	57
	Population*= 565			

*Peterson Index

TABLE IV-81
WHITE RIVER FISH SPECIES
(DAY NO. 2 RECAPTURES)

<u>Common Name</u>	<u>Generic Name</u>	<u>F-2</u>	<u>F-3</u>	<u>F-3</u>
Speckled dace	<i>Rhinichthys osculus</i>	74	53	41
Flannelmouth sucker	<i>Catostomus latipinnis</i>	0	19	14
Bluehead sucker	<i>Catostomus delphinus</i>	1	0	
Channel catfish	<i>Ictalurus punctatus</i>	0	25	2
Black bullhead	<i>Ictalurus melas</i>	0	1	
Roundtail chub	<i>Gila robusta</i>	0	3	2
Red shiner	<i>Notropis lutrensis</i>	0	3	107
Carp	<i>Cyprinus carpio</i>	<u>0</u>	<u>1</u>	<u> </u>
	Total	75	105	166

the baseline program. At a meeting in June 1976, a BLM representative apparently stated that a Colorado Division of Wildlife employee had collected a Colorado squawfish from the White River in Colorado. The employee was not available for comment, but the incident was discussed with the Colorado Division of Wildlife. At the time of the incident the employee was a graduate student and part-time employee of the division. He did collect a fish that he identified in the field as a Colorado squawfish, but the field identification was not verified, the specimen is no longer available, and written reports could not be located (Burkhardt 1976). Utah DWR and VTN data indicate that none of the four species of concern are present; since suitable habitat is available, however, they could occur.

3. INTERPRETATION AND CONCLUSIONS

The White River resembles many of the warm water streams of the Colorado River Basin (that is, the Yampa, San Juan, etc.). The water quality is hard and usually turbid, with suspended sand and silt. Transparency is sometimes less than 2.5 cm, and sheep or deer fecal pellets are found in the debris of nearly every invertebrate sample. The river's name was probably derived from the white salt crystals that form on the banks after the water level recedes from runoff events. Discharge varies from approximately 7 m³/sec to 85 m³/sec (250 cfs to 3000 cfs), with the peak usually occurring as a result of runoff from melting mountain snowpack in late June.

Periphyton growth is limited by turbidity and by the scouring action of high current velocity and suspended particles. When the water becomes low and clear in autumn, attached algae grow rapidly until limited by reduced temperature and photoperiod.

Phytoplankton is nearly all derived from periphyton that grows near the surface. Phytoplankton density is usually less than 100 cells/ml.

Macroinvertebrate populations are dominated in summer by mayflies (*Traverella albertana*, *Lachlania saskatchewanensis*, *Heptagenia elegantula*, etc.) and hydropsychid caddis larvae. In winter, stoneflies dominate the macrobenthos, with *Oemopteryx fosketti*, *Capnia* spp. and *Isogenoides frontalis* the most abundant. Chironomid larvae and tubificid worms are present in silted areas but rarely as dense populations. Diversity indices are usually between 2.0 and 3.0. Mollusks have not been found, and copepods were the only crustaceans found in one sample or the total program. Leeches were not found in the first year, but several fish captured in August 1976 were infested with *Illinobdella moorei*.

Fish populations, consisting of warm-water species, are scattered and difficult to sample. Red shiners (*Notropis lutrensis*) and flannemouth suckers (*Catostomus latipinnis*) are the most common species. Channel catfish are the only common species that could be considered a game fish. Sampling showed no detectable or persistent changes in population structures of the sampled populations as the river crosses the tracts. The biological importance of Evacuation Creek is limited because it is ephemeral. Because the stream occasionally dries up, most aquatic insect populations cannot become established. The stream does not support a fishery, although minnows and young-of-the-year suckers were noted on several occasions.

4. EVALUATION OF BASELINE PROGRAM

The aquatic program was successful in establishing baseline conditions of some parameters but was marginal for others. Future monitoring programs should be structured to take advantage of experience gained during the baseline period. For example, periphyton samplers must be left in the stream for approximately four weeks to provide data. During that period they are often either carried away by floating debris, or buried in silt. If the sampler cannot be visited daily, future investigators should consider the use of anchored bricks, concrete blocks, or tiles. Six or more samplers should be deployed at each station to assure that some will remain to provide samples. Samples might be taken by scraping several measured areas. Chlorophyll determinations should be performed locally to avoid the problems inherent in shipping to distant laboratories.

The periphyton data are limited and do not present a set of conditions that represent all seasons. Difficulties were caused by the inadequacy of standard sampling devices (some were destroyed or carried away) and the fluctuating water level (several samplers were stranded on the bank by receding water levels). Under normal conditions, periphyton productivity and standing crop are so variable that it would take several years of concentrated study to collect statistically defensible data. Standing crop biomass may go through rapid seasonal changes within short periods of time, but it would be difficult to show that the changes resulted from, or were limited by, the impacts of oil shale development.

Plankton samples contained high concentrations of suspended detritus and sediment. During most of the year, this material obscured much of the phytoplankton and reduced the accuracy of plankton counts. Straining the sample through a plankton net allowed most of the silt to escape, but many of the smaller diatoms were lost. Nevertheless, the method is repeatable.

Densities were determined and components were identified to the lowest practical taxon. As with periphyton, plankton concentration can change rapidly, particularly as a result of changes in water levels (Hynes 1970), and therefore plankton are of limited use in detecting impacts that might be caused by development.

Macroinvertebrate sampling was successful in determining species (genera in some cases) present and their relative density and diversity, parameters that have proved effective in detecting impacts such as those that could result from development. If future sampling programs are necessary, it is recommended that only two stations be used and that sampling be more intensive at those stations to increase the reliability and confidence limits of data.

Three groups of invertebrates would be suitable for evaluation during monitoring studies. They are (1) the summer group (2) those that occur in the winter, and (3) those that are present all year. Within each group, the most abundant species would probably provide the most usable data. The members of the summer group which might be most suitable for evaluation are the mayflies (*Traverella albertana* and *Lachlania Saskatchewanensis*). These are usually the most abundant insects, and have a distinctive appearance that would eliminate time consuming processes necessary for identification. Within the winter group the stoneflies (*Oemopteryx fosketti*, *Isogenoides frontalis* and/or *Capnia vernalis*) will serve the same purposes. There are many year-round resident invertebrates but many of them are difficult to enumerate or identify. The most suitable for study are probably the mayflies (*Heptagenia elegantula*, *Rhiphrogena undulata*) and the dragonfly (*Ophiogomphus severus*).

The fishery study was limited by natural conditions and the lack of a collecting permit. The sampling program defined the fish species that were present and, to some extent, their abundance. Most of the species present are relatively insensitive to minor amounts of pollutants, and the fishery may not react to low-level impacts of development. If future sampling work is done, it should include the use of trammel nets and intensive sampling of different habitats. The pool and rapids at F-1 and the riffles and large eddy at F-5 are representative of these areas.

The most important factor in a successful fisheries study will be selection of sampling areas and procedures. During the baseline period, large seines, minnow traps, and small electro shockers were found to be ineffective. The best capture success was achieved using a high-voltage truck-mounted shocker. If this procedure is not possible or practical during monitoring studies, the investigator will find small seines (1-6 m) suitable when they are used in meanders, backwaters or shallow riffles. Careful work in these areas will produce suitable numbers of representative species.

E. MICROBIOLOGY

The microbiology study was conducted to estimate the numbers of microorganisms and to measure biochemical activity in the soil, because such activity is the prime, and for all practical purposes the sole, factor in detritus and litter decomposition and mineral cycling. This section reports the results of data collected and analyzed over the two-year study period.

1. METHODOLOGY

The methodology for determining microbial activity is described in the First Year Environmental Baseline Report (FYEBR) and the May 19, 1976, revised biology resources program for the Partial Exploration Plan. A comprehensive description of the methodology is on file with the Area Oil Shale Supervisor's Office in Grand Junction, Colorado, as part of the final field data package for the baseline study.

Four microbiology sampling stations were established near soil survey pits 39, 50, 55, and 58 and were located with marked stakes. Figure IV-2 shows the relative positions of the sampling stations in the study area. These four sites--one in each vegetation type--were selected on the basis of their representativeness of the characteristic, dominant sub-ecosystems in the area: the mesa type (site 39), the juniper-dominated slope type (site 50J), the riparian type (site 55R), and the valley bottom, slightly saline type (site 58).

The most common species of vegetation at site 39 are cheatgrass, horsebrush, needle and thread grass, and big sagebrush; also present are hop sage, rabbitbrush, greasewood, and black sage.

The most common vegetation at site 50J is Utah juniper, and therefore litter samples were collected exclusively under its canopy. Greasewood, rabbitbrush, needle and thread grass, Galleta grass, and big sagebrush are the other major vegetation species at this location.

The vegetation at site 55R is mixed riparian dominated by cheatgrass and western wheatgrass. Other species at this site are annual mustards and yellow blossom sweet clover.

The vegetation at site 58 is mainly cheatgrass, rabbitbrush, big sagebrush, and blue mustard. Shadscale, greasewood, horsebrush, and prickly pear are other prevalent species.

The following designations indicate the depth at which the soil samples were taken:

39-1	Surface-3cm
39-2	5-20cm
39-3	40-50cm
50JC-1	2-4cm. beneath canopy of Utah juniper (<i>J. osteosperma</i>)
50JC-2	4-15cm. beneath canopy of Utah juniper
50JL	Surface, litter beneath canopy of Utah juniper
50JI-1	Surface-3cm, Interspace
50JI-2	5-20, Interspace
58C-1	Surface-3cm, beneath canopy of big sagebrush (<i>Artemesia tridentata</i>)
58C-2	5-20cm, beneath canopy of big sagebrush
58C-3	40-50cm, beneath canopy of big sagebrush
55R-1	Surface-3cm
55R-2	5-20cm
55R-3	40-50cm

For some specifically designated parameters, site 55R, the riparian location, was discussed separately because the environmental conditions there were more favorable. Tables and figures labeled as mean values of data from all sites refer to values averaged from sites 39, 50J, and 58 and do not include those of site 55R. Statistical methods were used to test the degree of correlation and variance between the most significant indicators of microbial activities.

2. SUMMARY OF RESULTS

a. Soil Chemical and Physical Characteristics

The chemical and physical characteristics of soil samples from survey pits 39, 55, and 58 are shown on Table IV-82. A detailed analysis of soil samples from site 50J (located away from a soil survey pit) is shown on Table IV-83. Percent organic carbon values overall were low, and in terms of a microbial energy-nutrient source, can be considered limiting. Salinity, as reflected by the $EC \times 10^3$ (electrical conductivity) values, does not directly limit microbial systems, although its influence on the total water potential may be to significantly inhibit microbial activities and proliferation. The salinity at site 58 in particular may be a prominent factor in this respect.

TABLE IV-82

SOIL ANALYSES OF STATIONS 39, 55 and 58

Sampling Station	Depth cm	Particle Size Distribution %				Textural Class*	pH Saturated Paste	Organic Carbon %
		Silt	Clay Hydrometer	Sand	> 2mm			
#39	0-4	9	8	83	4	LS	8.1	0.5
	4-17	11	11	78	7	SL	8.2	0.5
	17-35	8	10	82	25	LS	8.5	0.5
#55	0-5	31	9	60	4	SL	7.7	0.7
	5-15	35	10	55	3	SL	7.8	0.4
	15-40	39	10	51	5	L	7.8	0.3
	40-120	38	10	52	6	SL	8.0	0.4
	120-160	34	12	54	9	SL	7.7	0.3
#58	0-10	29	10	61	2	SL	9.9	0.5
	10-34	14	10	76	6	SL	10.4	0.3
	34-72	10	6	84	38	LS	8.0	0.3
	72-127	14	9	77	61	SL	8.0	0.2

*LS: loamy sand, SL: sandy loam, L: loam

TABLE IV-82

SOIL ANALYSES OF STATIONS 39, 55 and 58
(cont.)

Sampling Station	Depth cm	Electrical Conductivity (EC x 10 ³) mmhos/cm @25°C	CaCO ₃ %	Moisture @ 15 Atmos.		Extractable Cations NH ₄ OA meq/100 g			Available Phosphorus ppm P	Percent Moisture at Saturation
				@ 1/3 Atmos. %	@ 15 Atmos. %	Mg ²⁺	Na ⁺	K ⁺		
#39	0-4	0.6	3.0	8.1	4.6	1.0	0.3	0.4	16	29
	4-17	0.5	3.7	9.3	5.8	1.3	0.5	0.2	3.2	32
	17-35	0.3	6.8	10.4	6.3	1.0	0.5	< 0.1	1.0	38
IV-456										
	0-5	0.8	3.9	10.0	4.8	2.7	0.3	1.4	24	33
	5-15	0.6	3.1	11.0	5.5	2.5	0.3	0.5	2.6	28
	15-40	0.4	4.9	12.4	5.9	2.7	0.4	0.2	1.9	35
	120-160	16.0	6.0	14.6	6.4	4.4	6.7	0.3	9.2	34
#58										
	0-10	5.0	6.2	11.3	5.8	1.2	6.9	1.3	8.9	41
	10-34	12.0	5.7	8.7	6.6	0.4	10.3	0.3	10.9	30
	34-72	15.0	5.3	7.6	6.0	0.9	3.1	0.1	2.1	26
	72-121	3.5	14.6	10.8	5.8	1.5	1.4	0.1	1.8	28

TABLE IV-83
SOIL ANALYSIS OF STATION 50J

Analysis	Depth	
	0-3 cm	5-20 cm
pH	8.1	8.1
Salinity (ECe): mmhos/cm	0.4	0.6
Phosphorus: ppm	4.0	1.6
Exchangeable Sodium: eq/100 g	0.39	0.48
Exchangeable Magnesium: eq/100 g	0.02	0.04
Exchangeable Potassium: eq/100 g	0.37	0.14
Extractable Sodium: eq/100 g	0.42	0.58
Extractable Potassium: eq/100 g	0.37	0.14
Lime (CaCO ₃ equiv): %	2.5	17.9
Nitrogen (Nitrate): ppm	1.2	1.4
Nitrogen (Total): %	0.10	0.15
Organic Carbon: %	0.94	1.33
Water Soluble Sodium: eq/100 g	0.03	0.10
Water Soluble Magnesium: eq/100 g	0.01	0.02
Water Soluble Potassium: eq/100 g	0.01	0.01
Moisture (1/3 Atm): %	18.3	22.9
Moisture (15 Atm): %	6.8	10.7
Moisture (Saturation): %	34.0	45.0
Sand: %	53.0	48.0
Silt: %	33.0	35.0
Clay: %	14.0	17.0
Classification	SL (sandy loam)	L (loam)

b. Microbial Numbers

The results of the two years of sampling are shown on Appendices IV-11 through IV-45. For the four kinds of organisms studied--aerobic bacteria, anaerobic bacteria, streptomycetes, and fungi--three types of figures were plotted:

1. The average number of organisms per gram of soil per station for equivalent sampling dates in 1975 and 1976.
2. The mean number of organisms for all sites for 1975 and 1976.
3. The number of organisms at three different depths for 1975 and 1976.

The number of aerobic bacteria were relatively constant over the two-season sampling period because of the low influxes of moisture and nutrients. Values ranged between 1 million and 10 million organisms per gram of soil with an average of about 4 million per gram of soil. The number of organisms fluctuated the most in the soils of sites 58 and 50J, which may be attributed in part to the higher input of organic matter, especially in soils collected under the canopy (Appendices IV-11 through IV-16).

Marked changes in the number of organisms were also a function of season, as shown on Appendix IV-16. Numbers were generally highest in the spring because of the increased moisture available from snowmelt and the presence of organic substrates from decomposition processes, which are accelerated by rising temperatures; however, increased moisture also limits aeration, and decreased oxygen in the soil inhibits the growth of aerobic microorganisms. The higher percentage of moisture in these soils in spring 1975 is probably the reason for the lower numbers noted in 1975. The influence of decreased availability of substrates and water is reflected in the lower numbers observed in the summer. Numbers rose in the early fall and decreased as cooler temperatures became more common and the processes involved in cell growth were slowed.

Microbial numbers generally decreased with depth, as at site 39 in 1975; however, moisture was more limiting in 1976 (especially in the fall), and in the lower depths where moisture was retained, the number of bacteria present frequently exceeded that at the surface (Appendices IV-17 and IV-18).

Overall, the values for 1975 and 1976 were equivalent, and the same general trends were evident. The variations observed must be defined in terms of the physical and environmental conditions

prevailing at the time of sample collection, such as temperature, precipitation, and aeration.

Anaerobic Bacteria

As with aerobic bacteria, the number of anaerobes remained relatively constant throughout the season, with values ranging from 10,000 to 600,000 per gram of soil and averaging around 30,000 per gram of soil. There was a proliferation of anaerobes in spring 1975 because of the increased moisture and correspondingly lower oxygen availability; otherwise, the number of anaerobes was essentially equivalent during both years and followed the same general patterns (Appendices IV-19 through IV-24). The relationship between the number of anaerobes and depth at site 39 is seen in Appendices IV-25 and IV-26.

Streptomycetes

The number of streptomycetes ranged from 10^5 to 4×10^6 per gram of soil over the two-season sampling period, with an average for all sites of about 2 million per gram of soil. There were no observable trends between the two years, although similar fluctuations in values were evident. The highest values were noted at sites 50J and 58, due in part to the higher organic carbon influxes and increased moisture retention contributed by plant litter (Appendices IV-27 through IV-32).

The number of organisms decreased with depth and showed the same trends at depths of 5-20cm and 40-50cm depths over 1975. In 1976 the number did not necessarily decrease with depth, and no trends were evident between successive depths (Appendix IV-33 and IV-34).

Fungi

The number of fungi ranged from 10,000 to 380,000 per gram of soil, depending on the site and time of year. The average value for all sites over both sampling season was about 30,000 fungi per gram of soil. Numbers at all sites were highest in spring and substantially higher at sites 50JI, 58C, and 58I. Values decreased throughout summer and rose again in the fall, as a result of the added substrate provided by plant litter. Although marked variations were noted from early spring to summer, fungal populations remained nearly constant throughout the rest of the year (Appendix IV-35 through IV-40.)

Like streptomycetes, fungal populations in 1975 decreased with depth, and a pattern with respect to vertical distribution was evident throughout the year. In 1976, populations diverged considerably from this pattern, and no trends were discernible (Appendix IV-41 and IV-42).

Site 55R

In general, microbial populations at the riparian site were larger and fluctuated more widely than at the other sites in all parameters, because of moisture from the White River, dense vegetation, and fertility factors (Appendix IV-43 through IV-45. The number of aerobes ranged from 5×10^5 to 2×10^7 per gram of soil, and anaerobes, from 2×10^3 to 2×10^5 per gram of soil. The number of fungi averaged about 4×10^4 per gram of soil, from a high of 3.5 million to a low of 14,000 per gram of soil. Streptomycetes numbered from 3.2 million down to 130,000 per gram of soil, averaging about 1 million per gram of soil. The drier fall of 1976 was evident in the lower numbers in fall samples for all parameters for that year.

c. Microbial Activities

The results of the two years of sampling at each station are shown in Appendices IV-46 through IV-54. For each type of activity--respiration, dehydrogenase activity, and proteolytic activity--three kinds of figures were plotted by sampling date:

1. Microbial activity per sampling site for sampling dates in 1975 and 1976.
2. The mean values of microbial activity for all sites for 1975 and 1976.
3. Microbial activities at three different depths at site 39 for sampling dates in 1975 and 1976.

Respiration

The rate of release of CO_2 by soil microorganisms is indicative of biological activity, especially decomposition, in soil. Rates at the sampling sites were comparatively low overall (generally 50μ moles CO_2 evolved per gram of soil per minute), reflecting the low nutrient and energy levels in arid soils. In both sampling seasons, values ranged from 0 to 60μ moles $\text{CO}_2/\text{g}/\text{min}$ (Appendices IV-46 through IV-53).

Sites 50JC and 58C exhibited the highest rates of CO₂ release, and site 58I the lowest. Percent organic carbon data indicate that more usable substrate was available at sites 50JC and 58C. Lower organic carbon content and water potentials at sites 39 and 58I substantially decreased the biochemical processes, resulting in lowered evolution. The saline soil at site 58I is particularly inhibiting in this respect. Microbial respiration was generally highest in spring and fall and lowest in summer. This pattern was noted in both years. The rate of CO₂ release is highly dependent on moisture conditions in the profile, which are subject to constant change.

Dehydrogenase Activity

A soil's ability to reduce triphenyltetrazolium chloride (TTC) to its respective formazan is an indicator of total biological activity in the soil (Appendices IV-46 through IV-50). Dehydrogenase values ranged from 0.00 to 1.36 mg formazan/ml and averaged about 0.20 mg formazan/ml over the two sampling seasons. As with respiration, activity was highest at sites 50JC and 58C because of the greater amount of carbon substrate provided by litter. Dehydrogenase activity was generally highest in spring and decreased throughout the rest of the year. Soils with very low water potential (<-150 bars) often have dehydrogenase values equivalent to those usually found only in spring. This seems to be unique to arid regions, and investigations into the mechanisms involved are being examined by the USU soils laboratory. Dehydrogenase values decreased with depth and followed the same general patterns found in surface soils (Appendix IV-52 and IV-53).

Proteolytic Activity

The hydrolysis of gelatin by a soil is an indicator of the ability of the soil microorganisms to use a protein substrate. Potential values ranged from between 0% and 37% hydrolysis, averaging 20% for all sites for the two years of sampling. The highest potential for using the protein substrate was found at site 50JC, with other sites showing somewhat lower values. (Appendices IV-46 through IV-50).

Samples collected in 1975 showed that values were highest in spring and decreased throughout the rest of the year. In 1976 values generally decreased throughout spring and summer and were highest in late fall in both years (Appendix IV-51).

Proteolytic values decreased with depth and the 5-20 cm samples showed the same general trends as those of other surface soil samples. At the 40-50 cm depth, values were low and relatively constant during both years (Appendix IV-52 and IV-53).

Site 55R

Rates of dehydrogenase activity, respiration, and proteolytic activity at site 55R for 1975 and 1976 are shown on Appendix IV-54. Respiration values averaged about 10μ moles $\text{CO}_2/\text{g}/\text{min}$ higher than at all other sites and fluctuated considerably, depending on the season. The highest values were in March 1975 (60.7μ moles $\text{CO}_2/\text{g}/\text{min}$), and the lowest were in September 1975 (8.4μ moles $\text{CO}_2/\text{g}/\text{min}$). High moisture and nutrient conditons caused high respiration rates in the early spring of both years. Rates decreased rapidly with the approach of summer and lower water potentials. Rates increased slightly into late fall. Aside from a jump in activity noted in early July 1975, both years followed the same pattern.

Dehydrogenase activity ranged from between 0.93 mg formazan/ml and 0.05 mg/ml of formazan, averaging about 0.40 mg formazan/ml for both years. No clear patterns in activity were evident between the two years. Activity was highest in 1975 in early spring, summer, and late fall. In 1976 activity was highest in late spring, summer, and early fall.

Proteolytic activity was highest in 1976 and gradually decreased through the rest of the year. Activity in 1975 was considerably more variable--highest in late spring (29.0% hydrolysis) and summer samples, with fluctuations through the fall to a low of 5.0% in early November.

d. Moisture and Water Potentials

Percent moisture at saturation and percent moisture at -one-third bar and -15 bar for various depths at all sites are listed in Appendices IV-55 through IV-59. The percent moisture in all the soils studied was inversely proportional to their water potentials; however, the relationship is not direct. Physical and chemical factors in the soils, especially salinity, affect the various components of water potential such that the relationship between the percent moisture in the soil and the water potential is subject to change with time and depth as a response to varying environmental conditions.

Site 58 had the lowest potentials in both years, probably because of its saline soil environment. During both years moisture values at all sites were consistently highest in spring and lowest in summer. An increase in moisture was noted in fall 1975, but fall 1976 values remained equivalent to those of summer. Conversely, water potentials were highest (less negative) in spring and lowest in summer in 1976, but higher in fall 1975. Water content in the soils ranged from 26% to 1.2%, depending on the site and the season. Water potentials averaged more than -75 bars and ranged between -1.0 and -330 bars for all sites over both years (Appendix IV-60).

There did not appear to be any general patterns in the relationship of water potential and moisture with depth. Water retention in the soil profile was subject to constant change from wetting and drying conditions as a result of precipitation, temperature, wind, litter fall, and other environmental factors (Appendices IV-61 and IV-62).

Site 55R

Moisture and water potentials at site 55R during 1975 and 1976 are shown on Appendix IV-63. The White River contributes considerably to the water content of the soil at site 55. Percent moisture ranged from 32.0% to 2.2% and averaged a minimum of 5% higher than that of all the other sites. Consequently, water potentials were high (less negative). Percent moisture in the soils was higher in 1975 than in 1976, reflecting the low precipitation in the latter part of 1976.

e. pH Values

Appendices IV-64 and IV-65 list the pH values for 1975 and 1976, respectively. As expected, pH values in the soil samples at all sites were relatively constant over both years. The few changes observed were probably because of organic acids released during microbial decomposition in soils with higher organic matter (site 50JC) and possibly because of nitrification.

f. Total Fixed and Exchangeable Ammonium

Total ammonium (NH_4^+) data are listed in Appendices IV-66 and IV-67. In addition, fixed and exchangeable ammonium fluctuations in the surface soils are shown in Appendices IV-68 through IV-71, for 1975 and 1976. The values were highest overall for fixed and exchangeable NH_4^+ in site 50J soils and lowest in site

39 soils over both years. Exchangeable ammonium was highest at all sites in spring and very low or non-existent in summer, with general increases again in the fall. Although the magnitude of exchangeable ammonium values differed between sites, the same pattern was evident throughout. No trends were observable for fixed ammonium.

Most of the ammonium was in a fixed form. Fixed ammonium data for vertical distribution indicated the same pattern as in surface samples, but no significant increases or decreases with depth were evident (Appendices IV-72 and IV-73). Exchangeable ammonium, however, appears to be accumulated to a greater degree in lower horizons than at the surface in early spring, but it is essentially non-existent in summer and decreases with depth in fall.

g. Nitrogen Fixation Potential

The values for nitrogen fixation potential for 1975 and 1976 are listed in Appendices IV-74 and IV-75. No seasonal patterns in nitrogen fixation were observed during the dry season in the latter part of 1976, demonstrating that N_2 fixation activity peaks during favorable climatic conditions. As seen in Appendix IV-74 the peaks are displaced over different collection dates for each site in 1975. Activity at site 55R peaked in mid-spring, with steady moisture and low nutrient influx allowing a fairly consistent rate of fixation through the rest of the year.

Ammonium nitrogen data correlated well with fixation rates. Low levels of exchangeable NH_4^+ -N in the summer were evidence of decreased mineralization of organic-nitrogen forms. Carbon to nitrogen ratios (C/N) also indicated that this is the case: values were highest from mid-spring through summer, with a resultant increase in nitrogen immobilization. Values are expressed as grams of nitrogen fixed per hectare per hour of illumination, ranging from 0.03 to 1.40.

h. Organic Carbon Content

Percent organic carbon in surface soil at all sites for 1975 and 1976 are shown in Appendix IV-76. Values were highest at site 50JC and lowest at sites 39 and 58I. Sizeable increases occurred in late May and mid-September 1975 at sites 50JC, 50JI, and 55R but this trend was not observed in 1976. Values for sites 39 and 58I were generally consistent and low over both years because of the low influx of organic matter. Percent organic carbon at all sites ranged from 4.6% to 0.3%, with an average of about 1.0% for all sites (including 55R) over both years.

i. Total Nitrogen Content

The total nitrogen content of soils at all sites for 1975 and 1976 is shown on Appendices IV-77 and IV-78. Values at all sites were low and did not appear to fluctuate. Values increased at sites 50J and 58 in September 1976 and increased slightly at sites 58C, 55R, and 50JC in May 1976. As with organic carbon, values were highest at site 50JC and lowest at sites 39 and 58I over both years. The average value at all sites was about 0.10%, with a high of 0.31% and a low of 0.03%.

j. Nitrate (NO₃-N) Content

Values for nitrogen in the form of nitrate ranged from 0.0 µg/g to 16.0 µg/g at all sites. Values were conspicuously higher in spring of 1975 than in spring 1976 (Appendices IV-77 and IV-78). In March 1975 values were relatively low, increasing in April.

Nitrate is highly soluble, and at all sites it was subject to leaching with the beginning of snowmelt. As the moisture nitrate concentrations increased, these concentrations were short-lived as rapid uptake by plants soon depleted the nitrate pool. As moisture became limited, the rate of nitrification by soil microorganisms decreased, resulting in relatively constant values during the rest of the year.

k. Carbon:Nitrogen Ratio

Ratios of carbon to nitrogen are listed on Appendices IV-79 and IV-80. The ratio of percent organic carbon to percent total nitrogen (C/N) is a useful indicator of nitrogen status and provides additional data on the degree of organic matter decomposition in soils. C/N ratios ranged from 5.5 to 32.9 in surface soils at all sites. The highest values were in litter samples, as expected. The low input of carbon and generally favorable conditions for litter decomposition in seasonably warm moist soils of arid regions is evidenced by the low ratios generally observed at all sites. (Site 55R was again the exception, with its denser vegetation and higher moisture input from the White River). Low C/N ratios indicate that soil nitrogen is available for efficient litter decomposition.

1. ATP Concentration

Adenosine triphosphate (ATP) is a ubiquitous compound found in all living organisms. It represents a certain form of energy available to the cell and is therefore indicative of biological activity.

ATP concentrations for 1975 and 1976 are shown on Appendix IV-81. Values ranged from 0.1 to 14.1 micrograms of ATP $\times 10^{-2}$ per gram of soil and averaged considerably lower in 1976 than in 1975. As with all other activities measured, ATP concentration was found to be highly moisture-dependent. Concentrations were highest when moisture was most available (spring and fall 1975 and spring 1976). Also, as with other activities measured, the low precipitation in fall 1976 was reflected in decreased concentrations over this period.

ATP concentrations were significantly higher during the dry period at sites 58C and 50J than at other sites, indicating that soils higher in organic carbon substrate are less affected during droughts. Higher microbial numbers in these soils were the most responsible for these higher concentrations. For instance, during periods of high metabolic activity (that is, spring), respiration rates and cellular ATP levels may be at their seasonal highest; however, due to the biochemical systems involved, ATP is a transitory compound and may increase over a period when the respiration rate falls. This is because the rate of utilization of ATP is decreasing with respiration rate decrease, and as a result, a buildup in the ATP "pool" occurs.

Patterns were evident and were generally followed at all sites throughout the two years. ATP concentrations fluctuated considerably less by season in soils of low nutrient status, such as those at site 39, and were greater in soils collected in higher litter fall areas (especially under the canopy), such as those at sites 50J and 55R. In addition, because of the salinity of site 58 soils, there were large, abrupt fluctuations and hence ATP concentration may be a response to small moisture changes.

m. Nitrification Potential

At all sites the ability of the soil microorganisms to oxidize available ammonium to nitrite and nitrate fluctuated considerably over the seasons, and the patterns observed followed those of desert soils in general. A relatively long lag period (16 to 18 days) is necessary to build up the population of nitrifying organisms. Once this is done nitrification rates are rapid and ammonium is readily oxidized.

The nitrification potential of the soils at all sites is listed in Appendices IV-82 and IV-83. Site 58 soils showed the lowest potential for nitrification. Rates of ammonium oxidation were very low at this site for both sampling years and frequently non-existent. Conversion of ammonium to nitrate was highest at site 50J, although still relatively low when compared with the rates usually found in agricultural soils. Nitrification potential was higher in spring than in summer or fall, indicating that potentials are perhaps dependent on moisture and substrate to some degree. Nitrification potentials appeared to be higher in 1976 samples than in 1975 samples.

n. Litter Samples

Due to the higher organic carbon and nitrogen content in litter, moisture retention and other physical-chemical factors make litter a better environment than soil for soil microorganisms. Consequently, microbial numbers and activities were consistently higher in litter samples.

3. INTERPRETATION AND CONCLUSIONS

Tracts U-a and U-b are in a physiographically heterogeneous area with upland mesas and intersecting valleys with a variety of localized ecological, edaphic, and floristic areas, and therefore it would be futile to try to derive single "average" soil biochemical-biological values for the total area.

A baseline was not established for microbiological activities because in arid areas the soil nutrient characteristics and biological activities are dependent on, and regulated by, water availability. In arid areas, there is no typical, or average, year for these parameters because climatological variations (water availability from precipitation) are unique each year. Also, dependence of water availability on season introduces great variation in the parameters measured during an annual cycle, as was true of the collected data.

The data collected did, however, indicate that the soil biological activities of the tracts strongly resemble those of similar arid areas in Colorado and Utah. The data were also adequate to distinguish between individual ecological subsystems. For example, it was demonstrated that relatively small changes in soil salinity may produce large differences in microbial activities, and may regulate the decomposition and nitrogen cycle.

4. EVALUATION OF BASELINE PROGRAM

Generally, the two year-period was minimally adequate for evaluating changes due to future human activities. The soils were sampled and evaluated at each site according to accepted practices in soil science to assure statistical validity for each sample used. To date, the statistical results are far from definitive: significant relationships between microbial activities exist, but these relationships are complex and variable and subject to environmental conditions (that is, precipitation and temperature) and to soil chemical and physical factors. Adequate ecosystem-specific statistical models have not yet been developed to account for these complex system changes. Statistical treatments, however, have been useful in defining some of the limitations involved in microbial systems maintenance in an arid ecosystem soil.

F. ECOLOGICAL INTERRELATIONSHIPS

Natural ecosystems, such as the Utah oil shale tracts, are made up of a variety of abiotic and biotic components that interact in a dynamic way to produce a functionally integrated ecological system. The objectives of this section are to present a statistical analysis of the relationships of certain components and to describe in broad terms the structure and operation of this ecosystem.

1. SUMMARY OF RESULTS

The following is a statistical presentation of relationships of certain environmental components within the oil shale tracts.

- (1) Total annual precipitation in 1975 did not differ significantly from total annual precipitation in 1976, as indicated by the paired t-test statistics. However, the winter-spring (January through June) precipitation in 1975 was significantly greater than in 1976 (<99.9% level of confidence). Although annual (grasses and forbs) production was greater in 1975 than in 1976, it could not be demonstrated statistically because of the wide disparity of production values within each vegetation type. The greater production of annuals in 1975 compared to 1976 was probably a direct result of the greater winter-spring precipitation which occurred in 1975.
- (2) Fall 1975 precipitation was significantly greater than fall 1974 precipitation at the 95% level of confidence. Yet, annual production was much greater in 1975 than in 1976. Apparently, fall precipitation was not as important as winter-spring precipitation in influencing the vegetation production the following year.
- (3) Perennial shrub production was not significantly different from 1974 to 1975. Since precipitation data were not collected in early 1974 (the baseline did not begin until fall 1974), no statistical comparisons with overall perennial production could be made. However, mean sagebrush leader lengths at six collection sites were compared with interpolated precipitation isohyets for 1975 and 1976. All correlations were meaningless ($r=1.00$), since both winter-spring precipitation values and sagebrush leader lengths were greater in 1975. Sagebrush leader length in 1975 was significantly greater than in 1976 at the 95% level of confidence.
- (4) The percent of bare ground did not change significantly between years ($F=0.24$, ANOVA) for each of the four vege-

tation types measured in spring and fall of each year. The percent bare ground between vegetation types was significantly different for the same sampling periods.

- (5) Results of the two-year baseline study of microorganisms led to the conclusion that too much natural variability occurs in their populations as monitored by actual numbers, ATP concentration, dehydrogenase activity, respiration, and soil moisture. The limiting factor appears to be soil moisture availability, which could not be statistically correlated to any other parameter measured during the baseline study.
- (6) No significant correlations were found between precipitation and soil moisture potentials. Correlations between soil temperatures at the surface and at 30 cm depth and soil moisture potentials were nearly significant; however, soil moisture potential is affected by many other parameters, such as soil particle size and osmolarity (i.e., same osmotic pressure).
- (7) Terrestrial invertebrates for all practical purposes are similar to microorganisms in that their populations have a high natural variability and there are so many species that statistically adequate sampling is not practical with currently available collecting techniques and nomenclature.

2. INTERPRETATION AND CONCLUSIONS

The tracts are part of the Great Basin Desert, the largest desert in North America. Biologists classify deserts (arid lands) as areas of low annual precipitation, high incident radiation, relatively low levels of soil carbon and perhaps nitrogen, and high meteorological variability.

Much of the biological activity in deserts is hidden from view. Most of the plant and animal biomass is underground, and many of the animals are nocturnal. Some of the most important activities and processes in deserts are inconspicuous, such as detritus food chains and biogeochemical cycles.

Many of the traditional conceptions about the structure and function of desert ecosystems are only now being disproved by research. For instance, deserts are sometimes thought of as relatively simple, predictable ecosystems, when in truth the unpredictable meteorological events and the plasticity of desert organisms make it difficult to predict the responses of deserts to perturbations. Deserts are also considered fragile systems. While it is true that arid environments recover slowly from some types of disturbances, desert organisms also exhibit great

resilience and adaptability. Most biologists consider the relative aridity and relatively low levels of soil carbon and nitrogen in desert to be chronic stressors of organisms living there. This assumption may be more a product of man's predilections for the agronomic use of land and for his own physical comfort than the product of empiric inquiry. Scientists have yet to show that sagebrush is less fit for its environment than an oak tree is for its environment.

a. Climate

The climate of the tracts, like that of the Great Basin Desert, is characterized by low precipitation and wide temperature ranges. Precipitation occurs for the most part during the late fall, winter, and early spring, and results in a rather consistent annual recharge of soil moisture. Localized thunderstorms provide virtually the only rainfall during the hot, dry summer and fall, but the moisture from these storms contributes little to net primary production. Annual precipitation on the tracts averages 23 cm to 28 cm. Temperature means vary from about 15° to 35°C in July to about 0° to -15°C in January.

The microclimates on the tracts vary widely because of differences in topography, vegetative cover, altitude, and the nature of storms during the growing season. The influence of terrain and plant cover is evident in the difference between surface temperature, soil moisture, and wind velocity beneath a shrub on a north slope and one on a bare southwest slope. The interaction between abiotic components and vegetation in creating microclimates which vary widely from the general climate of the tracts is largely responsible for the biotic diversity of the tracts.

Cold air drainage and temperature inversions occur on the tracts because temperature differentials, which may be as much as 10°C between riparian areas and adjacent upland areas 200 m to 300 m higher. During winter the animals that are able to do so tend to move out of the cold and humid riparian areas to higher and warmer ground.

Rainfall during the growing season tends to be random and unpredictable in time, space, and intensity, which limits the biota and contributes to microclimatic variations. A thunderstorm in one area may leave 2 cm to 3 cm of rain in a few hours, cause severe erosion, start germination in annual plants, and create a bloom in microorganism populations, while leaving areas several kilometers away completely dry.

b. Soils

The substrate of the tracts consists of exposed bedrock, broken pieces of rock of various sizes, and soil. Although the percent coverage of each is unknown, the non-soil components of the substrate are substantial. Most of the soils are poor from an agronomic point of view. They are low in organic material, retain moisture poorly, and are shallow. The only soils of any depth are those under the larger plants, in valley bottoms, and along the watercourses.

The primary reason for the lack of deep soils over most of the tracts is heavy erosion, caused by the occasional intense rainstorms, annual spring run-off, wind, and a hilly topography of sandstone bedrock. The erosion is increased to some unknown degree by livestock, which tends to cause continual sloughing of soil in the interstices between the larger plants, especially on the steeper slopes. The condition perpetuates itself, since few plants are able to grow in the eroded areas on steeper slopes to prevent erosion. The lack of moisture and the poorly developed soils must be considered major limiting factors to the potential biotic productivity of the tracts.

The soil characteristics, in large measure, dictate the kind of plant community an area will support. Animal communities are more a reflection of the plants that directly or indirectly support them than of the soils. However, there are some animals on the tracts that are directly dependent on soil type and soil depth for their existence. Kangaroo rat habitat typically includes loose, sandy soil such as that along the broader washes of the tracts. The shallow, porous soils on hillsides, especially in the interstices between shrubs, support few fossorial animals. The environment is often too dry for much microbial activity. Bedrock presents a physical barrier to invertebrates, such as harvester ants and termites, which normally establish large subsurface colonies. Vertebrate ectotherms, such as lizards, and heterotherms, such as ground squirrels, cannot exist in soil that prevents them from hibernating below the frost line.

c. Microbiology

Microorganisms play a major role in the cycling of nutrients in all natural ecosystems. They do this either by breaking down organic material into chemical elements, which are then available to plants, or by transforming nutrients into a form that is usable by plants. If these processes are slowed or halted, plant growth is reduced or stopped. Perhaps the most critical of the nutrient cycles in deserts are the nitrogen and carbon cycles.

Three major microbial processes on the tracts contribute to plant nitrogen. The first process is nitrogen fixation by microorganisms near the soil surface and in the presence of moisture. The second process is nitrogen fixation by microorganisms in the rhizosphere. Although this second process has long been associated with legumes only, recent research suggests that fixation may occur in the root zones of desert soils as well. The third process is the recycling of nitrogen within the ecosystem. Microorganisms transform the nitrogen found in dead animals and plant tissue to nitrates, which are then reused by plants. The cycle is probably the one most susceptible to disruption on the tracts: anything that interferes with the microbes, with the moisture necessary for their activity, or with the detritus they decompose tends to break or slow the cycle. Although it is certain that each of these processes contributes nitrogen to the soil of the tracts, the relative contribution of each is unknown. The amount of soil nitrogen present is low for agricultural fields but about average for desert soils. Since little is known about the nitrogen requirements of native desert plants, little can be said about the adequacy of plant nitrogen on the tracts.

Soil carbon is important because it is the energy source for microbial populations. With carbon in short supply, the action of microbes in the decomposition process and in the production of nitrates is reduced. There is relatively little soil carbon (humus) in the soils of the tracts, and what carbon there is occurs beneath the larger plants, which tend to collect organic carbon by preventing detritus from dispersing. Substantial amounts of carbon may be lost from the tracts through livestock grazing and through the passage of sheep fecal material to the White River by wind and water erosion. The degree to which the low levels of soil carbon affects, and limits net productivity on the tracts is not known, but it is known that the interrelationships between factors that control the pathways and rates of biogeochemical cycles, to which microbes are inexorably bound, are among the most important on the tracts.

d. Vegetation

The tracts are a part of a salt desert shrub community that grades into pigmy conifer in the more rugged terrain. The plant communities on the tracts form a patchwork of four vegetation types with a large amount of interface between types. There are patches of riparian vegetation in the bottomlands along the White River. Shadscale covers most of the rolling hills above the river. The dominant vegetation in the higher valleys and along the dry washes are sagebrush and greasewood. At the highest elevations and on some of the steeper slopes, juniper is the dominant vegetation.

Most of the larger plants on the tracts function beyond their normal role as autotrophs. On slopes of anything more than a few degrees, each shrub and tree forms a barrier to the movement of soil particles and litter by wind and water erosion. The build-up of material improves the moisture-holding characteristics of the substrate around the plants. Algal crusts, which contribute soil nitrogen to the system, form on the ground beneath some of the plants. In this moist litter and soil, invertebrates and microorganisms can flourish and form detritus food chains that play an important role in soil genesis. These areas also support small vertebrates. Biogeochemical cycles are complete within the microhabitat the plant helps to create and physically protect. Thus, a shrub which begins to a small barrier to erosion becomes the center of a small, relatively self-contained biological community complete with functions that modify the microclimate, protect the microhabitat, cycle nutrients, and transform energy.

Most of the vegetation biomass of the tracts is made up of shrubs and pigmy conifer. These plants are widely spaced, as indicated by the fact that about 85% of the tracts are bare ground. These bare areas are mostly shallow soils with low organic content, poor moisture retention characteristics, and low biological activity. In the more eroded interstices, roots tend to be confined to fractures in the bedrock. Thus, the small islands of biological activity around trees and shrubs are essentially the unit of ecological function on the tracts. As such, their number, size, and condition are keys to the status of the ecological community. Any factor that tends to change the number, size, or condition of these islands has an important impact upon the environment of the tracts.

The shrub and tree micro-islands are rather uniformly spaced on the tracts. Three major factors influence their distribution: competition in the interstices for the available water and nutrients, the biotic and abiotic limits to the size that plants and their microhabitats can attain as well as how close the micro-islands can be to each other, and sheep grazing. Sheep in a shrub community move in the interstices from shrub to shrub, cropping from each. This activity tends to promote erosion and destruction of any small plants in the interstices, while the micro-islands are protected from sheep by the presence of shrubs.

e. Invertebrates

Invertebrates play an important role in most natural ecosystems at all consumer trophic levels. Recent research has suggested that invertebrates have a much greater impact upon ecosystems than do native vertebrates. Invertebrate carnivores and herbivores probably move more energy and material through the ecosystem per unit time than do their vertebrate counterparts.

Desert invertebrates have an especially important function in detritus food chains. They are responsible for the initial processing of dead material, a vital first step in the cycling of nutrients necessary for plant growth. Termites, harvester ants, and spring-tails are some of the most common of these organisms. Without the activity of these invertebrates, most litter would not be available to decomposer organisms, and important biogeochemical cycles would be broken. Disruption of the detritus food chain on the tracts would most certainly sharply reduce the amount of nitrogen available to plants.

Entire taxa of vertebrates rely on the diversity and numbers of invertebrate populations. Many vertebrates eat invertebrates, and most herbivores and granivores, such as juncos and ground squirrels, will switch to a diet of invertebrates during the summer.

Some invertebrates have unique relationships with other segments of the community. Insect pollinators are necessary for reproduction in some plants, and there are many invertebrate pest species on the tracts. Homeotherms carry several types of ectoparasites, including biting midges, mosquitoes, and deer-flies. The latter two organisms may cause some mammals, such as deer, to move away from the riparian habitat during the day. Grasshoppers and sagebrush defoliators are numerous in some areas of the Great Basin Desert and have a considerable impact on the vegetation. The tracts may not have enough sagebrush or they may be too ecologically diverse to support any outbreaks of the insects.

f. Vertebrates

The tracts contain a diverse vertebrate fauna--more per hectare than in most typical desert shrub communities--in which beaver, whiptail lizards, and plain titmice can be found within a few hundred meters of one another. The richness of the fauna is due to the diverse habitats created by the topography and by the patchy mixture of vegetation types.

Recent studies in deserts indicate that native vertebrates usually are the least important component of the ecosystem from a biological point of view. In a majority of cases, it is difficult to measure the impact of vertebrate species, and consequently it is difficult to measure how much environmental change would occur if deer, fence lizards, or horned larks were removed. However, it is fairly safe to assume (1) that vertebrate granivores collectively do not so deplete the seed reserves so that plant propagation is curtailed, (2) that native vertebrate herbivores do not significantly decrease the net productivity of plants except perhaps under unusual circumstances, and (3)

that vertebrate insectivores do not significantly limit insect populations over the long term. Native vertebrates are more likely to have an impact upon like vertebrates than upon other components of the biotic community, i.e., a lizard exerts a greater influence upon conspecifics or upon like lizards than it does upon insect populations.

There are, however, some vertebrate populations that have considerable impact upon the environment of the tracts or that hold particular interest for people, or that have unique interrelationships with other elements of the biotic community. These include deer, beaver, coyotes, livestock, birds, and rodents.

Deer

Mule deer are of particular interest for people because they are the major big game hunted in the area. Within the dynamics of the ecosystem functioning on the tracts, however, they are a relatively insignificant species; they have little effect as herbivores (as compared to other species or taxa) and are not a prey base for any predators.

The population of the region around the tracts from which local residents may come to hunt is approximately 15,000 persons. According to the U.S. Department of Agriculture, one person consumes approximately 185 pounds of meat per year, and thus the average annual consumption of meat in the region is approximately 2.7 million pounds per year. Assuming that each harvested deer provides 100 pounds of meat, the average number of deer harvested on the tracts provides approximately 1200 pounds of meat, or less than 0.001% of the meat consumed in the region each year. Based on those figures, the deer on the tracts should not be considered an economic huntable resource in the region. Although mule deer are not ecologically or economically significant, they are of interest on the tracts as a recreational resource for both hunting and observing.

Beaver

A population of bank beaver lives along the White River. The beaver's pattern of habitat use is to make a den in the river bank and to feed upon shrubs and small trees in an ever-widening circle around the den. When the distance between the food supply and the den becomes too great for their convenience or safety, the animals move to another stretch of river and repeat the process. After ten or more years, they may return to the original area. The effect of this pattern of exploitation is to cycle secondary plant succession between early and

intermediate seral stages. Beaver tend to delay or prevent the development of mature plant communities along the river, a circumstance that benefits cattle and most wildlife. The activity also may increase the instability of river banks and may increase the chance that the river will alter its channel.

Coyotes

Although the coyote population is suspected to be low due to trapping and eradication programs, coyotes probably are the most numerous large vertebrate carnivore on the tracts as compared with the two bobcats and lack of mountain lions sighted. Although coyote density is unknown, it would probably be relatively stable (without the effects of trapping and eradication programs) given the nature of the natural prey base, which does not fluctuate greatly from year to year. There are no jack-rabbits or microtinae rodents on the tracts, which in some areas strongly influence coyote numbers with their widely fluctuating densities. Cottontails may exert this kind of influence but to a lesser extent than truly irruptive prey species.

Coyotes usually do not follow sheep populations from area to area (F. Knowlton, pers. comm.). The sheep may become an additional source of food to some of the coyotes that normally live on the tracts during winter grazing; however, coyote scat analysis showed no evidence of sheep as a food source. Trapping and control programs implemented by the USF&WS in 1974 in the area apparently reduced coyote populations, but also may have induced an in-migration of coyotes from surrounding areas and caused reproductive rates to increase in the coyotes that remained.

Livestock

Livestock undoubtedly have a greater impact on the environment of the tracts than any other vertebrate group, including humans. Approximately 160 cattle graze in riparian vegetation along the White River from June 1 to October 31 annually. A cow averaging 450 kg of body weight and with a nursing calf requires about 20.9 Kcal of gross energy (E_g) in dry plant material per day. About 35% of this energy, or 5.4 Kcal, is returned to the substrate as feces (E_f), leaving about 15.5 Kcal of plant matter that is removed from the grazing area per cow (assimilation energy or E_a). The assumed relationship is $E_a (65) = E_g (100\%) - E_f (35\%)$. Thus, the 160 cows with calves on the tracts eat a calculated 511,632 Kcal (300,960 kg dry weight) of vegetation per year from riparian and adjacent up-land areas from Asphalt Wash to Hells Hole Canyon; 35% of this

amount is returned to the tracts as feces, and 65% or 195,600 kg is assimilated by the cattle. The cattle also trampled significant amounts of vegetation. The impact of cattle upon the tracts as a whole is relatively small, since the tracts contain little riparian habitat.

Sheep graze intensively over most of the tracts. Approximately 7000 sheep graze in three allotments in and around the tracts during the winter and early spring. Assuming that the sheep (pregnant ewes) average 54 kg body weight and gain about 168 g/day during winter maintenance, each sheep consumes about 6.0 Kcals of plant energy per day. Approximately 4.4 Kcal is returned to the environment. Part of the fecal material remains in the terrestrial habitat, and part is lost to the aquatic community (see "aquatics," Section g). Thus, the 7000 sheep eat about 3,652,500 Kcal (2,148,529 kg dry weight) of plant material while they are in the area. Perhaps one-half of this amount is from the tracts. Feeding may increase or decrease the vigor of the plants and the micro-communities beneath them depending upon grazing intensity of plant material.

Although the amount of plant material consumed by sheep certainly affects the ecological characteristics of the tracts, their mode of grazing may have a greater effect on the ecological characteristics. Sheep tend to move in the spaces between plants, stopping at each palatable plant to eat. Feeding removes some of the plant material and decreases the litter available to the detritus food chains, but in addition, sheep movement tends to intensify the erosive process in the plant interstices and thus, may tend to increase the size of well-established islands and prevent the generation of new islands. Sheep probably have increased the shrub micro-island effect (1) by increasing the number of large islands, although reducing the vigor of these islands, (2) by decreasing the number of small islands, and (3) by increasing the amount of bare ground between the shrubs. Removal or reduction in the numbers of sheep might increase the vigor of existing shrub micro-islands but probably would not significantly alter the current equilibrium for many years.

Birds

Bird populations were the most completely studied terrestrial vertebrate group on the tracts because they are the most conspicuous and therefore relatively easy to sample. For this reason the relationship between birds and the ecosystem can be discussed in more detail than the other vertebrate groups. The most commonly used approach is to relate the avian community structure to habitat parameters (MacArthur and MacArthur 1961; Balda 1969; Whitmore 1975; and others).

In this discussion the specific objectives were to relate (1) biomass, (2) species diversity, (3) bird size, and (4) species shared by habitats to the four major plant communities on the tracts through a year.

Bird biomass through the year was greatest in the riparian habitat. However, excluding the presence of Canada geese in April, the riparian and sagebrush-greasewood sampling areas would have been quite similar in average monthly biomass (500 g/ha to 600 g/ha). Juniper (217 g/ha) and shadscale (174 g/ha) averaged about the same in avian biomass. Bird biomass in June was 184 g/ha in shadscale, 351 g/ha in juniper, 685 g/ha in sagebrush-greasewood, and 752 g/ha in riparian. These data compare with Wiens and Nussbaum (1975), who found an average of 519 g/ha of passerines in six plots in spruce-fir forest habitats in June.

Bird species diversity were calculated using an equation from Shannon and Weaver (1949): $H^1 - E_{p_i} \ln_e P_i$. Species diversity varied considerably, ranging from 0.000 to 2.942, through the year on all of the transects, rising from low levels during the winter months to peak values in June. In most months, the species diversity of birds was greatest on the riparian transects and least on the shadscale transects. These results conform with commonly accepted views on community structure (MacArthur and MacArthur 1961).

For all habitats through the year, "small" birds (11g to 25g, after Weins 1974) were the most abundantly represented class. "Tiny" birds (<11g) were generally less abundant and were for the most part confined to habitat with vertical diversity as well as horizontal variation (e.g., riparian habitat with tall cottonwoods, intermediate salt cedar and willow, and low shrubs and grasses). Birds in the "very large" size class (<300g) were rare. In general, these findings are consistent with those of Weins (1974), who found that 11g to 25g species tended to predominate in shrub-steppe habitats and that "tiny" species were absent in such habitats.

Ambient temperatures may influence the local dispersion of birds (Shields and Grubb 1974); the smaller the bird, the more it is affected by low temperatures (Gates 1969). Winter temperatures on the tracts may have influenced the dispersion of some of the smaller species. The upland riparian habitat was the most temperate habitat in winter in terms of wind and temperature. The riparian habitat along the White River was the coldest, and the shadscale ridges were the windiest. Relatively more "tiny" and "small" birds were found in the upland riparian habitat during the winter than in other habitats. Birds of medium size or larger, being energetically more efficient than smaller birds, could better withstand winter weather conditions in other habitats.

Some bird species were observed in only one vegetation type, whereas others were found in two or more types. Of the 85 species recorded on transects in 1975, 54% occurred in only one habitat type, 14% in two, 17% in three, and 15% in four habitat types. Whereas only 6% to 12% of the species observed on transects in juniper, sagebrush-greasewood, or shadscale were unique to those vegetation types, 52% of the species seen on riparian transects were not recorded elsewhere. Riparian birds accounted for 80% of the species unique to a particular habitat, which conforms to concepts of relative niche breadth and plant community complexity.

The application of Kulczynski's coefficient of community

$\frac{2W}{2+b} \times 100$ as described by Culberson (1955) indicates the degree to which habitats share species. Avifaunal similarities among vegetation types were greatest for juniper and sagebrush-greasewood, least for shadscale and riparian, and intermediate for other habitat types.

Rodents

Nocturnal rodent biomass (dry weight) was estimated to be 80 g/ha in shadscale, 181 g/ha in riparian, 211 g/ha in juniper and 203 g/ha in sagebrush-greasewood communities. These figures were obtained by processing the data obtained from the 1975 trapping grids with the Small Mammal Density and Home Range Computer Program developed by the US/IBP Desert Biome program (Balph et al. 1974). The impact of these animals upon the plant communities of the tracts is unknown; however, estimates can be made for some species.

The diet of pocket mice in desert communities is thought to consist of 2.01 g/day (8.3 Kcal) plant material and 0.35 g/day (2.0 Kcal) arthropods (computation based on Becker 1977). The diet of deer mice consists of 1.69 g/day (7.4 Kcal) plant material and 0.75 g/day (3.2 Kcal) arthropods.

The estimated population density of pocket mice on the tracts was 2.37/ha in juniper, 3.45/ha in sagebrush-greasewood, 1.08/ha in shadscale, and 0.62/ha in riparian. The estimates for deer mice were 1.46/ha in juniper, 4.82/ha in sagebrush-greasewood, 3.30/ha in shadscale, and 1.33/ha in riparian vegetation. These estimates compare favorably with those of Shinn et al. (1975) for deer mice (0.9-3.8/ha) and pocket mice (0.5-9.5/ha) in sagebrush and shadscale communities.

Thus, during each day in the summer, the pocket mice and deer mice ate an estimated 16.88 g/ha of plant material and 3.75 g/ha of arthropods in juniper, 46.94 g/ha of plant material and

10.85 g/ha of arthropods in sagebrush-greasewood, 59.44 g/ha of plant material and 6.97 g/ha of arthropods in shadscale, and 12.29 g/ha of plant material and 2.88 g/ha of arthropods in the riparian community. Obviously, this rate of consumption is a small fraction of the plants and arthropods present. However, it should be pointed out that (1) the above estimates are rough, (2) mice do not select food strictly in proportion to the availability of food, and (3) mice may destroy food without eating it.

g. Aquatics

Aquatic ecosystems within deserts occupy a small part of the area; however, much evidence indicates that their importance is disproportionately large. Water in the desert, whether it be a temporary pool, an intermittent stream, or a river, is the site of intense biological activity, and the water itself provides the medium for a well-defined biotic community.

Desert aquatic areas also are disproportionately interrelated with adjacent terrestrial areas. Many terrestrial vertebrates need regular access to free water, and consequently their behavior patterns are governed by its availability. Numerous terrestrial invertebrates and amphibians are dependent upon surface water, since their larvae are aquatic. The availability of ground water around permanent water sources allows for the development of a unique flora and fauna. Perhaps most important, desert water sources often are the focal point of human activity and its accompanying impacts.

The White River is the largest aquatic ecosystem on the tracts. Like all large aquatic systems, it is relatively stable environment. Water volume, temperature, nutrient availability, and light penetration change little from day to day, and most of the changes that do occur follow cyclical events and thus are highly predictable in terms of effect on the aquatic community. The most important of these cyclical events is spring runoff. At this time, the quantity of water increases rapidly. The silt load of the river, which is high at any time, increases disproportionately during runoff. Silt scours the riverbed and reduces light penetration. Both processes tend to decrease primary production by removing aquatic plants from the river bottom and by reducing photosynthesis.

The most significant interrelationship between the river and terrestrial components of the tracts is the riparian habitat which the river supports. Silt from the river provides the substrate for the habitat, and water from the river maintains it. Thus, the aquatic system indirectly supports cattle, many migratory birds, trees, and all the other organisms which are unique to the riparian environment.

3. INDICATOR SPECIES

An indicator or indicator organism should ideally possess the following attributes:

- (1) long lived
- (2) large body size
- (3) reproduces over many years
- (4) efficient
- (5) displays strong intra- and inter-specific competition
- (6) population size fairly constant in time and at or near carrying capacity (saturated communities)
- (7) mortality is density-dependent

A good indicator organism is one that is K-selected. A K-selection endpoint represents one evolutionary qualitative extreme - the environment is saturated with organisms, competition is high, and the optimal "strategy" of the species is to channel all available matter and energy into production of a few extremely fit offspring. K-selection leads to increasing efficiency of utilization of environmental resources. R-selection on the other hand is the opposite evolutionary extreme. The optimal "strategy" is to put all possible matter and energy into reproduction of as many progeny as possible with the smallest practical amount into each individual.

Vertebrates are generally K-selected as compared to invertebrates and microorganisms which are R-selected. Therefore, animal indicator species should be found among the vertebrates. Vegetation indicators should possess the same K-selected attributes. Thus, short-lived annuals should not be considered good indicator species, but perennial dominant shrubs should be good indicator organisms. The following list contains indicators which warrant particular attention in an on-going monitoring program.

<u>Component</u>	<u>Rationale</u>
<u>Vegetation</u>	
Total Cover and Bare Ground during Fall	Fall transect measurements would indicate changes in the relatively stable cover of shrubs and perennial plants.

Component

Rationale

Vegetation

Dominant shrub height

Fall transect measurements performed concurrently with cover measurements would indicate changes in general condition of perennial vegetation.

Species frequency
inventory

Fall transect measurements performed concurrently with cover and height measurements would indicate changes in species composition and diversity.

Wildlife

Population estimates of
the following species:

Populations were relatively high and relatively stable during the two years of monitoring

Sagebrush lizard
Western whiptail
Golden eagle
Pinyon jay
Whitetail antelope
squirrel
Apache pocket mouse
Ord Kangaroo rat
Mule Deer

Glossary

GLOSSARY

Abiotic: of or pertaining to non-living characteristics.

Amphibian: any of a class (Amphibia) of vertebrates including frogs, toads, and salamanders that usually begin life in water as tadpoles with gills and later develop lungs; they have body temperatures approximating ambient temperatures and are scaleless.

Annual: a plant which completes its life cycle in one year or one growing season.

Arthropod: any of a phylum of invertebrates including crustaceans, insects, spiders, centipedes, and millipedes that have jointed appendages and hard exoskeletons.

Arachnids: spiders, ticks, mites; arthropods with eight legs.

A.U.M.: (Animal unit month) - the amount of forage on an acre of land required to support one cow or five sheep for one month.

Autotrophs: organisms which are capable of producing organic substances from inorganic materials by means of energy received from outside of the organisms, e.g., plants with chlorophyll and certain bacteria.

Avifauna: collectively, the birds characteristic of a particular area.

Benthic: bottom-dwelling.

Biota: collective flora and fauna of any particular area.

Biotic: of or pertaining to live; biological.

Canopy: the uppermost layer consisting of crowns of trees or shrubs in a forest or woodland.

Causality: the existence of regularities which control natural phenomena.

Community: collectively, all of the populations inhabiting a common environment and interacting with each other.

Ecology: the study of the interactions that determine the distribution and abundance of organisms.

Ecosystem: collectively, all populations in a community, plus the associated environmental factors.

Ecotone: a transition line or strip of vegetation between two communities which has characteristics of both kinds of neighboring vegetation as well as characteristics of its own.

Ectotherm: an organism with an external heat source such as a lizard or snake.

Edge: that area between two communities, c.f. ecotone.

Endangered species: a legal classification of those species in danger of extinction throughout all or a significant portion of their range.

Ephemeral: short-lived existence.

Fauna: collectively, the animal life of any particular area or of any particular past time.

Flora: collectively, the plant life of any particular area or of any particular past time.

Fungus: pl. fungi; molds, mildews, mushrooms, rusts, and smuts which are parasitic or saprophytic.

Habitat: place where an animal or plant normally lives, often characterized by a dominant plant form of physical characteristic.

Heterotherms: refers to homeotherms that at times behave like poikilotherms and lose their powers of thermo regulation.

Homeotherms: an animal which is able to maintain the temperature of its body at an approximate constant level independent of the surrounding medium.

Invertebrate: collectively, all animals without a vertebral column.

Irruptive: tending to irrupt, to undergo a sudden upsurge in numbers.

Larva: general term for any independent, active, immature stage of an animal which is morphologically quite unlike the adult; grows into an adult by a complicated metamorphosis in most cases.

Legume: any member of the leguminosae such as beans, peas, alfalfa, clover, etc.

Macrophytes: macroscopic aquatic plants, generally those that are visible without optical magnification.

Metamorphosed: a marked structural change in an animal during postembryonic development.

Micro-environment: a distinctive unit of a larger environment.

Niche: place or position occupied by, or a type of activity engaged in by, an organism with reference to other organisms.

Perennial: a plant which lives for two years or longer.

Phenology: the study of the periodic phenomena of animal and plant life and their relations to the weather and climate, e.g., the time of flowering in plants.

Phytoplankton: collectively, all those microscopic plants suspended in the water of aquatic habitats; includes algae and fungi.

Population: all of the individuals belonging to a single species occupying a particular area or space.

Primary production: assimilation (gross) or accumulation (net) of energy and nutrients by plants and other autotrophs.

Range: geographic area in which a particular organism, species, other taxon, or community occurs.

Raptor: collectively hawks, falcons, owls, vultures, and eagles.

Reptile: any of a class (reptilia) of vertebrates including snakes, lizards, turtles, tortoises, etc.: they have body temperatures approximating ambient temperatures and are covered with scales or scutes.

Riparian: pertaining to the bank or shore of a river, lake or stream.

Seral: one of a complete set of changes from initiation to climax in a community.

Species: the classification level of biological nomenclature which categorizes each group of related organisms potentially capable of interbreeding; the accepted level of classification to differentiate one specific type of organism from another (e.g. Ursus Americanus, the black bear, is differentiated as a separate species from Ursus horribilis, the grizzly bear).

Steppe: plant community lacking trees, such as a sagebrush-steppe.

Streptomycetes: any of a genus of fungus-like, chiefly soil, bacteria.

Threatened species: those species which are likely to become endangered within the foreseeable future throughout all or a significant portion of their range.

Zooplankton: collectively, all those animals suspended in the water of an aquatic habitat which are not independent of currents and water movements; most such organisms are microscopic and commonly include protozoans, rotifers, and small crustaceans.

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Appendix

Vegetation type:
G = sagebrush-grasswood
J = juniper
S = shrubscale
R = riparian

frequency of transect observation based on a maximum of 15 observations in each habitat for each sampling period (5 transects vegetation type, walked five times each sampling period)

Abundance
n = individuals observed

Mean distance from transect line
 $\bar{x}$ = mean distance

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APPENDIX IV-1
(Cont.)

ORDER		December		February		April		June		August		October	
		1) 1974	2) 1975	1) 1975	2) 1976	1) 1975	2) 1976	1) 1975	2) 1976	1) 1975	2) 1976	1) 1975	2) 1976
Family	Genus species	G	J	S	R	G	J	S	R	G	J	S	R
Common name		G	J	S	R	G	J	S	R	G	J	S	R
Anas	<i>strepera</i>	1	-	-	-	-	-	-	.07	-	-	-	-
	Gadwall	2	n=2	-	-	-	-	-	$\bar{x}=30m$	-	-	-	-
Branta	<i>canadensis</i>	1	-	-	-	-	-	-	.47	-	-	-	.07
	Canada Goose	2	n=13	-	-	-	-	-	$\bar{x}=20m$	-	-	-	$\bar{x}=10m$
			n=13	-	-	-	-	-	$\bar{x}=33m$	-	-	-	-
FALCONIFORMES													
Cathartidae	<i>aura</i>	1	-	-	-	-	-	-	.33	-	-	-	.33
	Turkey Vulture	2	n=10	-	-	-	-	-	$\bar{x}=15m$	n=9	-	-	$\bar{x}=18m$
			n=7	-	-	-	-	-	.20	-	-	-	-
			-	-	-	-	-	-	$\bar{x}=24m$	-	-	-	-
Accipitridae	<i>jamaicensis</i>	1	-	-	-	-	-	-	.07	-	-	-	.07
	Red-tailed Hawk	2	n=2	-	-	-	-	-	$\bar{x}=50m$	n=1	-	-	$\bar{x}=50m$
			n=1	-	-	-	-	-	.07	-	-	-	.20
			-	-	-	-	-	-	$\bar{x}=1m$	n=1	-	-	$\bar{x}=45m$
			-	-	-	-	-	-	.07	-	-	-	.20
			-	-	-	-	-	-	$\bar{x}=39m$	n=3	-	-	$\bar{x}=60m$
Falconidae	<i>merriamii</i>	1	-	-	-	-	-	-	.07	-	-	-	-
	Prairie Falcon	2	n=1	-	-	-	-	-	$\bar{x}=150m$	n=1	-	-	$\bar{x}=50m$

APPENDIX IV-1
(Cont.)

ORDER Family Genus species Common name	December			February			April			June			August			October				
	1) 1974 2) 1975			1) 1975 2) 1976			1) 1975 2) 1976			1) 1975 2) 1976			1) 1975 2) 1976			1) 1975 2) 1976				
	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R
FALCONIFORMES (Cont.)																				
Falconidae (Cont.)																				
<i>Falco sparverius</i>	1	-	-	-	.07			.33	-	.20	.07	-	.07	.13	-	.07	-	-	-	-
Kestrel	2	n=1						X=92m	n=4	X=29m			n=3	X=19m		n=1			X=1m	
					.20	.07		.33	.13	-		.20	-	.13	-					
					n=15			X=20m	n=6	X=35m			n=2	X=120m						
CHARADRIIFORMES																				
Scolopacidae																				
<i>Actitis macularia</i>	1							.33	-	-	-	-	-	-	-	.27				
Spotted Sandpiper	2							n=8	X=39m	n=6			n=6	X=19m						
								-	-	-	-	.40	-	-	-	.33				
								n=14	X=44m	n=5			n=5	X=23m						
Charadriidae																				
<i>Charadrius vociferus</i>	1							.20	-	-	-	-	-	-	-	.20				
Killdeer	2							X=6m	n=4				n=5	X=5m						
								X=1m	n=1				-	-	-	-				
COLUMBIFORMES																				
Columbidae																				
<i>Zenaidura macroura</i>	1							.13	.47	.40	.20	.67	.80	.47	.60	.67	-	-	-	.33
Mourning Dove	2							X=18m	n=10	X=23m			n=163	X=14m		n=5			X=16m	
								.07	.40	.40	.27	.40	.13	.07	.27		-	-		.07
								X=20m	n=3	X=20m	n=46	X=20m	n=10	X=26m		n=1			X=3m	

ORDER
Fami
Gen
Com

IV-301

ORDER	Fami	Gen	Comm
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IV-302

ORDER	Family	Genus species	Common name	December		February		April		June		August		October			
				1) 1974	2) 1975	1) 1975	2) 1976	1) 1975	2) 1976	1) 1975	2) 1976	1) 1975	2) 1976				
				G	J	S	R	G	J	S	R	G	J	S	R	G	J
PASSERIFORMES (Cont.)																	
Tyranidae (Cont.)																	
		<i>Empidonax wrightii</i>	1							.33	.40		.07	.13			
		Gray Flycatcher	2							n=17		$\bar{x}$ =14m	n=3		$\bar{x}$ =7m		
											.60		.07				
										n=14		$\bar{x}$ =18m	n=1		$\bar{x}$ =1m		
Hirundinidae																	
		<i>Petrochelidon</i>	1														
		<i>pyrrhonota</i>															
		Cliff Swallow	2							n=390		$\bar{x}$ =28m					
											.20		.27				
										n=34		$\bar{x}$ =18m	n=14		$\bar{x}$ =38m		
Tachycineta																	
		<i>thalassina</i>	1										.07	.07			
		Violet-green Swallow	2							n=2		$\bar{x}$ =1m	n=10		$\bar{x}$ =4m		
										.13							
										n=4		$\bar{x}$ =6m					
Stelgidopteryx																	
		<i>ruficollis</i>	1													.33	.13
		Rough-winged Swallow	2										n=21		$\bar{x}$ =2m		.13
																$\bar{x}$ =41m	

ORDER	Fami	Gen	Comm
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IV-304

ORDER

IV-305

ORDER	Fami	Gen	Cont
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IV-306

APPENDIX IV-1
(Cont.)

ORDER Family Genus species Common name												
	December			February			April			June		
	G	J	S	R	G	J	S	R	G	J	S	R
PASSERIFORMES (Cont.) Parulidae (Cont.)												
<i>Icteria virens</i> Yellow-breasted Chat	1											
	2											
<i>Wilsonia pusilla</i> Wilson's Warbler	1											
	2											
Icteridae												
<i>Stumella neglecta</i> Western Meadowlark	1											
	2											
<i>Agelaius phoeniceus</i> Red-winged Blackbird	1											
	2											
<i>Icterus parisorum</i> Scott's Oriole	1											
	2											
<i>Icterus</i> Northern Oriole	1											
	2											

ORDER

IV-309

APPENDIX IV-1
(Cont.)

ORDER Family Genus species Common name												
	December			February			April			June		
	G	J	S	G	J	S	G	J	S	G	J	S
PASSERIFORMES (Cont.) Fringillidae (Cont.)												
<i>Amphispiza bilineata</i> 1												
Black-throated Sparrow 2												
<i>Amphispiza belli</i> 1												
Sage Sparrow 2												
<i>Spizella passerina</i> 1												
Chipping Sparrow 2												
<i>Spizella breweri</i> 1												
Brewer's Sparrow 2												
ANSERIFORMES												
FALCONIFORMES												

[illegible]

ORDER	Fami	Gen	Comm
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PASSERIFORMES (Cont.)

APPENDIX IV-2

OBSERVATIONS FOR AVIAN WINTER RESIDENTS

Legend

Vegetation type:
G = sagebrush-greasewood
J = juniper
S = shrubscale
R = riparian

Frequency of transect observation based on a maximum of 15 observations in each habitat for each sampling period (3 transects/vegetation type, walked five times each 5 ampling period)

Abundance

n = individuals observed

Mean distance from transect line
 $\bar{x}$ = mean distance

ORDER	Family	Genus species Common name												
			G	J	S	R	G	J	S	R	G	J	S	R
FALCONIFORMES	Accipitridae	<i>Accipiter gentilis</i> Goshawk	December				February				April			
			1) 1974 2) 1975				1) 1975 2) 1976				1) 1975 2) 1976			
	Haliaeetus <i>leucocephalus</i> Bald Eagle	1												
			n=1				n=1				n=1			
			$\bar{x}$ = 300m				$\bar{x}$ = 75m				$\bar{x}$ = 1m			
			$\bar{x}$ = 300m				$\bar{x}$ = 50m				$\bar{x}$ = 30m			
			$\bar{x}$ = .07				$\bar{x}$ = .07				$\bar{x}$ = .07			

APPENDIX IV-2
(Cont.)

ORDER	Family	Genus species	Common name	December			February			April			June			August			October		
				1) 1974			1) 1975			1) 1975			1) 1975			1) 1975			1) 1975		
				G	J	S	G	J	S	G	J	S	G	J	S	G	J	S	G	J	S
PASSERIFORMES																					
Paridae																					
		<i>Psaltiriazus minimus</i>		1	-	.07	-	.07	-	.07	-	.07	-	.07	-	.07	-	.13	-	.13	
		Common Nuthatch		2	n=24	x=28m	n=35	x=11m	n=35	x=11m	n=35	x=11m	n=35	x=11m	n=35	x=11m	n=35	x=11m	n=35	x=6m	
Fringillidae																					
		<i>Leucosticte atrata</i> *		1	-	.07	-	.07	-	.07	-	.07	-	.07	-	.07	-	.07	-	.07	
		Black Rosy Finch		2	n=355	x=4m	n=355	x=4m	n=355	x=4m	n=355	x=4m	n=355	x=4m	n=355	x=4m	n=355	x=4m	n=355	x=4m	
		<i>Junco hyemalis</i>		1	-	.13	-	.13	-	.13	-	.13	-	.13	-	.13	-	.13	-	.13	
		Dark-eyed Junco		2	n=22	x=19m	n=108	x=11m	n=215	x=11m	n=215	x=11m	n=215	x=11m	n=215	x=11m	n=215	x=11m	n=215	x=6m	
		<i>Spizella arborea</i>		1	-	.47	-	.47	-	.47	-	.47	-	.47	-	.47	-	.47	-	.47	
		Tree Sparrow		2	n=108	x=11m	n=215	x=11m	n=215	x=11m	n=215	x=11m	n=215	x=11m	n=215	x=11m	n=215	x=11m	n=215	x=14m	
		<i>Spizella arborea</i>		1	-	.33	-	.33	-	.33	-	.33	-	.33	-	.33	-	.33	-	.33	
		Tree Sparrow		2	n=47	x=8m	n=47	x=8m	n=47	x=8m	n=47	x=8m	n=47	x=8m	n=47	x=8m	n=47	x=8m	n=47	x=3m	
PASSERIFORMES																					
		<i>Spizella arborea</i>		1	-	.07	-	.07	-	.07	-	.07	-	.07	-	.07	-	.07	-	.07	
		Tree Sparrow		2	n=5	x=7m	n=5	x=7m	n=5	x=7m	n=5	x=7m	n=5	x=7m	n=5	x=7m	n=5	x=7m	n=5	x=60m	

*Includes some *Leucosticte*
leucoptera-Gray-crowned Rosy Finch

OBSERVATIONS FOR AVIAN TRANSIENTS

Vegetation type:
G = sagebrush-greasewood
J = juniper
S = shrubscale
R = riparian

Frequency of transect observation based on a maximum of 15 observations in each habitat for each sampling period (3 transects/vegetation type, walked five times each sampling period)

frequency of transect observation based on a maximum of 15 observations in each habitat for each sampling period (3 transects/vegetation type, walked five times each sampling period)

Abundance
n = individuals observed

Mean distance from transect line
x = mean distance

[illegible]

[illegible]

APPENDIX IV-3
(Cont.)

ORDER Family Genus species Common name	December			February			April			June			August			October		
	1) 1974			1) 1975			1) 1975			1) 1975			1) 1975			1) 1975		
	2) 1975			2) 1976			2) 1976			2) 1976			2) 1976			2) 1976		
	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R		
PASSERIFORMES																		
Hirundinidae																		
<i>Hirundo rustica</i>																		
Barn Swallow																		
Corvidae																		
<i>Neotifraga columbiana</i>																		
Clark's Nutcracker																		
Paridae																		
<i>Parus gambelii</i>																		
Mountain Chickadee																		
Sittidae																		
<i>Sitta carolinensis</i>																		
White-breasted Nuthatch																		
<i>Sitta carolinensis</i>																		
Red-breasted Nuthatch																		
Certhiidae																		
<i>Certhia familiaris</i>																		
Brown Creeper																		

[illegible]

ORDER

IV-319

APPENDIX IV-4
OBSERVATIONS FOR AVIAN PERMANENT RESIDENTS

Legend

Vegetation type:

G = sagebrush-greasewood

J = juniper

S = shrub-cane

R = riparian

Frequency of transect observation based on a maximum of 15 observations in each habitat for each sampling period (3 transects/vegetation type, walked five times each sampling period)

Abundance

n = individuals observed

Mean distance from transect line

$\bar{x}$ = mean distance

ORDER Family Genus species Common name	December			February			April			June			August			October		
	1) 1974			1) 1975			1) 1975			1) 1975			1) 1975			1) 1975		
	2) 1975	G	J	2) 1976	G	J	2) 1976	G	J	2) 1976	G	J	2) 1976	G	J	2) 1976	G	J
FALCONIFORMES																		
Accipitridae																		
<i>Circus cyaneus</i>	1																	
Marsh Hawk	2																	
<i>Accipiter cooperii</i>	1																	
Cooper's Hawk	2																	

ORDER

IV-321

ORDER

IV-322

APPENDIX IV-4
(Cont.)

ORDER	Family	Genus species Common name	December				February				April				June				August				October																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
			1) 1974 2) 1975	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																													
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1 <i>Parus atricapillus</i> Black-capped Chickadee			-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Legend

Vegetation type:
G = sagebrush-greasewood
J = juniper
S = shadscale
R = riparian

Frequency of transect observation based on a maximum of 15 observations in each habitat for each sampling period (3 transects/vegetation type, walked five times each sampling period)

Abundance
n = individuals observed

Mean distance from transect line
 $\bar{x}$ = mean distance

APPENDIX IV-5

OBSERVATIONS FOR UNCLASSIFIED AVIANS

ORDER																								
Family	Genus species Common name		December			February			April			June			August			October						
			G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R		
STRIGIFORMES																								
Strigidae																								
<i>Asio otus</i>																								
1		Long-eared Owl					-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		
							n=1																	
2			-	-	-	-	$\bar{x}=40m$																	
			n=1																					
											</													

ORDER

IV-325

APPENDIX IV-6

OBSERVATIONS FOR MAMMALIAN PERMANENT AND SEASONAL RESIDENTS

Legend

Vegetation type:
G = sagebrush-greasewood
J = juniper
S = shadscale
R = riparian

Frequency of transect observation based on a maximum of 15 observations in each habitat for each sampling period (3 transects/vegetation type, walked five times each sampling period)

Abundance
n = individuals observed

Mean distance from transect line
 $\bar{x}$ = mean distance

ORDER	Family	Genus species Common name	December				February				April				June				August				October			
			1) 1974		2) 1975		1) 1975		2) 1976		1) 1975		2) 1976		1) 1975		2) 1976		1) 1975		2) 1976		1) 1975		2) 1976	
			G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R
RODENTIA	Sciuridae																									
		<i>Marmota flaviventris</i>																								
		Yellow-bellied Marmot																								
																			</							

APPENDIX IV-6
(Cont.)

ORDER	Family Genus species Common name	December			February			April			June			August			October			
		1) 1974			1) 1975			1) 1975			1) 1975			1) 1975			1) 1975			
		2) 1975			2) 1976			2) 1976			2) 1976			2) 1976			2) 1976			
G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	
RODENTIA (Cont.)																				
Sciuridae (Cont.)																				
	<i>Spermophilus</i>																			
1	<i>lateralis</i>																			
2	Golden-mantled Squirrel																			
																		</		

APPENDIX IV-6
(Cont.)

ORDER Family Genus species Common name		December				February				April				June				August				October			
		1) 1974				1) 1975				1) 1975				1) 1975				1) 1975				1) 1975			
		2) 1975				2) 1976				2) 1976				2) 1976				2) 1976				2) 1976			
		G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R	G	J	S	R
RODENTIA (Cont.)																									
Erethizontidae																									
<i>Erethizon dorsatum</i>	1	-	-	-	-	n=2	-	-	.13	-	-	-	.07	-	-	-	-	-	-	-	-	-	-	-	-
Porcupine	2	n=10	-	-	.60	n=11	-	-	.47	n=3	-	-	.20	n=1	-	-	.50m	n=1	-	-	.07	-	-	-	.20
					$\bar{x}=40m$				$\bar{x}=30m$				$\bar{x}=58m$								$\bar{x}=10m$	n=3	-	-	$\bar{x}=53m$
Leporidae																									
<i>Sylvilagus audubonii</i>	1	.13	-	.27	.13	-	-	.47	-	.13	-	.13	.13	.20	.27	.47	.60	1.00	.53	.67	.33	.53	.87	.40	.40
Desert Cottontail	2	n=12	.67	.27	.13	n=17	.67	.27	.47	n=8	.47	.40	.53	.87	.93	.80	.67	.93	.51	.87	.20m	n=79	.93	.93	.93
		n=80		$\bar{x}=31m$		n=44		$\bar{x}=35m$		n=48		$\bar{x}=21m$		n=150		$\bar{x}=17m$		n=293		$\bar{x}=15m$		n=361		$\bar{x}=17m$	
ARTIODACTYLA																									
Cervidae																									
<i>Odocoileus hemionus</i>	1	-	.13	-	.13	-	-	-	-	-	-	-	.07	-	.07	-	.80m	-	-	.27	-	-	-	-	.27
Mule Deer	2	n=13		$\bar{x}=81m$		n=5				n=5			.07	n=2		$\bar{x}=80m$		.13	n=6	$\bar{x}=48m$	n=15	-	-	-	.07
													$\bar{x}=328m$					n=8		$\bar{x}=94m$	n=4	-	-	-	$\bar{x}=31m$
CHIROPTERA																									
Vesperilionidae	1	-	-	-	-	-	-	-	-	-	-	-	.07	-	-	-	.07	.27	.07	-	.27	-	.07	-	-
Plain-nose Bats	2									n=5		$\bar{x}=34m$		n=16		$\bar{x}=4m$		.27	n=45	.07	.53	n=1	-	-	$\bar{x}=1m$
																									$\bar{x}=12m$

APPENDIX IV-7

RODENTS CAPTURED PER 100 TRAP NIGHTS IN FOUR VEGETATION TYPES DURING JUNE AND AUGUST

Legend

Vegetation type:
G = sagebrush-greasewood
J = juniper
S = shadscale
R = riparian

		June					August						
		1) 1975		2) 1976			1) 1975		2) 1976				
		G	J	S	R	G	J	S	R	G	J	S	R
RODENTIA													
Sciuridae													
<i>Ammospermophilus</i>	1	-	>1	-	-	1	-	>1	-	-	-	-	-
<i>Leucurus</i>													
White-tailed Antelope Squirrel	2	>1	1	>1	-	>1	-	-	-	>1	-	>1	2
Spermophilus													
<i>lateralis</i>	1	>1	>1	-	-	-	-	-	-	-	2	-	-
Golden-mantled Squirrel	2	-	-	-	-	-	-	-	-	-	3	-	-
Eutamias spp													
	1	-	1	-	-	2	-	-	8	11	7	8	13
	2	-	2	-	-	>1	-	-	10	16	17	13	31
Heteromyidae													
<i>Perognathus apache</i>	1	4	2	>1	-	3	4	2	>1	-	-	-	-
Apache Pocket Mouse	2	4	2	2	>1	4	1	2	>1	-	5	-	-
Dipodomys ordii													
Ord's Kangaroo Rat	1	2	-	>1	>1*	>1	-	2	2	-	-	-	-
	2	3	-	2	1*	>1	-	1	1*	>1	2	>1	-
RODENTIA (Cont.)													
Cricetidae													
<i>Petithodonomys megalotis</i>	1	>1	-	>1	-	-	-	>1	-	-	-	-	-
Western Harvest Mouse	2	>1	-	-	-	>1	-	-	-	>1	-	>1	2
Peromyscus crinitus													
Canon Mouse	1	-	2	-	-	-	-	-	2	-	2	-	-
	2	-	6	-	-	-	-	-	6	-	3	-	-
Peromyscus maniculatus													
Deer Mouse	1	9	6	7	8	11	7	8	13	17	13	17	31
	2	11	8	10	16	17	13	17	31	-	-	-	-
Peromyscus truei													
Pinon Mouse	1	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	2	-	-	-	-	5	-	-	-	-	-
Peromyscus boylii													
Brush Mouse	1	-	-	-	-	-	-	-	-	-	-	>1	-
	2	-	-	-	-	-	-	-	-	-	-	-	-
Neotoma lepida													
Desert Woodrat	1	>1	1	-	-	>1	1	2	>1	-	-	-	-
	2	>1	3	>1	>1	1	7	2	>1	-	-	>1*	-
Neotoma cinerea													
Bushy-tailed Woodrat	1	-	-	-	-	-	-	-	-	-	-	-	-
	2	-	-	-	>1*	>1	>1	>1	>1	>1	>1	>1	>1*

APPENDIX IV-8

ARTHIPOD GROUPS DETERMINED BY OTHERS

Specialists Acknowledged and Institutions Concerned

Group	Specialist	Institution
Araneida	W.J. Gertsch	Amer. Mus. Nat. Hist., N.Y.
Collembolla	D.L. Wray	N.C. State Univ.
Ephemeroptera	Richard Bauman	Brigham Young Univ., Utah
Plecoptera	Richard Bauman	Brigham Young Univ., Utah
Trichoptera	Richard Bauman	Brigham Young Univ., Utah
Hemiptera	J.L. Herring	U.S. Dept. Agr., USNM
Homoptera		
Aphididae	G.F. Knowlton	Utah State Univ.
Psyllidae	M.B. Stoetzel	U.S. Dept. Agr., USNM
All others	J.P. Kramer	U.S. Dept. Agr., USNM
Coleoptera		
Chrysomelidae	R.E. White	U.S. Dept. Agr., USNM
Coccinellidae	R.D. Gordon	U.S. Dept. Agr., USNM
Scarbaeidae	R.D. Gordon	U.S. Dept. Agr., USNM
Cantharidae	R.D. Gordon	U.S. Dept. Agr., USNM
Hydrophililidae	P.J. Spangler	U.S. Nat. Mus., USNM
Dytiscidae	P.J. Spangler	U.S. Nat. Mus., USNM
Nitidulidae	W.A. Connell	Univ. Kansas
Dasytidae	J.M. Kingsolver	U.S. Dept. Agr., USNM
Melyridae	J.M. Kingsolver	U.S. Dept. Agr., USNM
Pselaphidae	J.M. Kingsolver	U.S. Dept. Agr., USNM
Mycetophagidae	J.M. Kingsolver	U.S. Dept. Agr., USNM
Bruchidae	J.M. Kingsolver	U.S. Dept. Agr., USNM
Phalacridae	J.M. Kingsolver	U.S. Dept. Agr., USNM
Ptilidae	J.M. Kingsolver	U.S. Dept. Agr., USNM

IV-8 (Cont.)

Group	Specialist	Institution
Dermestidae	J.M. Kingsolver	U.S. Dept. Agr., USNM
Colydiidae	J.M. Kingsolver	U.S. Dept. Agr., USNM
Cerylonidae	J.M. Kingsolver	U.S. Dept. Agr., USNM
Cerambycidae	T.J. Spilman	U.S. Dept. Agr., USNM
Tenebrionidae (in part)	T.J. Spilman	U.S. Dept. Agr., USNM
Rhipiphoridae	T.J. Spilman	U.S. Dept. Agr., USNM
Carabidae	T.L. Erwin	U.S. Natl. Mus.
Heteroceridae	T.L. Erwin	U.S. Natl. Mus.
Oedomeridae	R.H. Arnett	Siena College, N.Y.
Anthicidae	Floyd Werner	Univ. Arizona
Lathridiidae	Floyd Werner	Univ. Arizona
Staphylinidae	Jan Moore	U. Calif. at Riverside
Lepidoptera		
Noctuidae	J.D. LaFontaine	Biosystematic Res. Inst., Ottawa
Arctiidae	J.D. LaFontaine	Biosystematic Res. Inst., Ottawa
Pyralidae	A. Mutuura	Biosystematic Res. Inst., Ottawa
Geometridae	K.B. Bolte	Biosystematic Res. Inst., Ottawa
Diptera		
Stratiomyidae	Wilford Hanson*	Utah State University
Ceratopogonidae	W.W. Wirth	U.S. Dept. Agr., USNM
Drosophilidae	W.W. Wirth	U.S. Dept. Agr., USNM
Ephydriidae	W.W. Wirth	U.S. Dept. Agr., USNM
Mycetophilidae	R.G. Gagne	U.S. Dept. Agr., USNM
Sciaridae	R.G. Gagne	U.S. Dept. Agr., USNM

IV-8 (Cont.)

Group	Specialist	Institution
Cecidomyiidae	R.G. Gagne	U.S. Dept. Agr., USNM
Scatopsidae	R.G. Gagne	U.S. Dept. Agr., USNM
Sarcophagidae	R.G. Gagne	U.S. Dept. Agr., USNM
Calliphoridae	R.G. Gagne	U.S. Dept. Agr., USNM
Muscidae	R.G. Gagne	U.S. Dept. Agr., USNM
Simuliidae	F.C. Thompson	U.S. Dept. Agr., USNM
Tipulidae	G.W. Beyers	Univ. Kansas
Culicidae	T.F. Gaffigan	U.S. Dept. Agric., USNM
Dolichopodidae	F.C. Harmston	U.S. Public Health (Ret.)
Milichiidae	C.W. Sabrosky	U.S. Dept. Agr., USNM
Carnidae	C.W. Sabrosky	U.S. Dept. Agr., USNM
Chloropidae	C.W. Sabrosky	U.S. Dept. Agr., USNM
Tachinidae	C.W. Sabrosky	U.S. Dept. Agr., USNM
Anthomyzidae	C.W. Sabrosky	U.S. Dept. Agr., USNM
Agromyzidae	George Steyskal	U.S. Dept. Agr., USNM
Trixoscelidae	George Steyskal	U.S. Dept. Agr., USNM
Chamaemyiidae	George Steyskal	U.S. Dept. Agr., USNM
Sphaeroceridae	George Steyskal	U.S. Dept. Agr., USNM
Sciomyzidae	George Steyskal	U.S. Dept. Agr., USNM
Anthomyiidae	George Steyskal	U.S. Dept. Agr., USNM
Hymenoptera		
Torymidae	E.E. Grissell	Fla. State Plant Board, U. of Fla.
Pteromalidae	C.M. Yoshimota	Biosystematics Res. Ints., Ottawa
Cynipoidea	C.M. Yoshimoto	Biosystematics Res. Inst., Ottawa
Eulophidae (in part)	Gordon Gordh	U.S. Dept. Agric., USNM

IV-8 (Cont.)

Group	Specialist	Institution
Proctotrupoidea	L. Masner	Biosystematics Res. Inst., Ottawa
Braconidae	Paul Marsh	U.S. Dept. Agr., USNM
Ichneumonidae	Robert Carlson	U.S. Dept. Agr., USNM
Bethylidae	H.E. Evans	Colo. State Univ.
Pompilidae	Marius Wasbaeur	Calif. State Dept. Agr.
Sphecidae	R.M. Bohart	Univ. Calif. Davis
Formicidae (in part)	G.C. & J. Wheeler	Desert Res. Inst., Reno, Nev.

*Dr. Hanson also assisted in many other determinations at U.S.U.

APPENDIX IV-9

SPECIES LIST - INSECTS AND SPIDERS OIL SHALE TRACTS Ua AND Ub

INSECTA (2210)

- COLLEMBOLA (29)
Poduridae (10)
 Brachystomella parvula Schaeffer
 Hypogastrura armata (Nicolet)
 Hypogastrura matura Folsom
 Hypogastrura promatro Wray
 Onychiurus armatus (Tullberg)
 Onychiurus ramosus Folsom
 Tullbergia collis Bacon
 Tullbergia granulata Mills
 Willemia similis Mills
 Xemulla grisea Axelson
Entomobryidae (12)
 Entomobrya marginata Tullberg
 Entomobrya nivalis (L.)
 Folsomia fimetaris (L.)
 Folsomides parvus Folsom
 Isotoma eunotabilis Folsom
 Isotomurus palustris (Muller)
 Lepidocyrtus cyaneus Tullberg
 Proistoma americana Mills
 Proistoma aquae Bacon
 Pseudosinella octopunctata Börner
 Pseudosinella sexoculata Schott
 Pseudosinella violenta Folsom
Sminthuridae (7)
 Arrhopalites caecus Tullberg
 Bourletiella juanitae Maynard
 Deuterosminthurus repandus (Agren)
 Sminthurides pumilis (Krausbauer)
 Sminthurinus aureus Lubbock
 Sminthurinus elegans Fitch
 Odontella conifer Mills
DIPLURA (1)
Campodeidae (1)
 Campodeidae No. 1
THYSANURA (2)
Lepismatidae (1)
 Thermobia No. 1
Machilidae (1)
 Machilidae No. 1
EPHIMEROPTERA (4)
Baetidae (1)
 Baetus No. 1
Tricorythidae (1)
 Tricorythodes No. 1
Caenidae (1)
 Caenidae No. 1
Heptageniidae (1)
 Heptageniidae No. 1
PLECOPTERA (2)
Perlodidae (2)
 Isogenoides colubrinus (Hagen)
 Isoperla longiseta Banks
ODONATA (10)
Aeschnidae (1)
 Aeschna interrupta Walker
Libellulidae (4)
 Libellula forensis Drury
 Sympetrum obtrusum Hagen
 Sympetrum occidentalis
 Sympetrum No. 1
Lestidae (1)
 Lestes congener Hagen
Coenagrionidae (3)
 Enallagma carunculatus Morse
 Ischnura cervula Selys
 Ischnura perparva Selys
Agrionidae (1)
 Hetaerina americana (Fabricius)
ORTHOPTERA (29)
Acrididae (17)
 Aeloplides tenipennis Scudder
 Ageneotettix deorum Scudder
 Arphia frigida Scudder
 Arphia pseudometa Thomas
 Aulocara ellioti (Thomas)
 Camnula pelucida (Scudder)
 Chortophaga viridifasciata (DeGeer)
 Circotettix verruculatus (Kirby)
 Conozoa carinata Rehn
 Cratypedes neglectus (Thomas)
 Dissastera carolina (L.)
 Melanoplus complanatus Scudder
 Melanoplus bivittatus Say
 Melanoplus differentialis Thomas
 Melanoplus mexicanus Saussure
 Melanoplus packardii Scudder
 Trimerotropis cyaneipennis (Brunner)

SPECIES LIST - OIL SHALE TRACTS

-2-

ORTHOPTERA (CONT'D)

Tettigoniidae (5)

- Anabrus simplex* Hald
Capnobotes fuliginosus Thomas
Conocephalus fasciatus Morse
Eremopedes No. 1
Idiostatus No. 1

Gryllacrididae (1)

- Stenopalmus fuscus* Hald

Tetrigidae (1)

- Paratettix cucullatus* Burmeister

Gryllidae (4)

- Acheta assimilis* Fabricius
Oecanthus californicus (?) Saussure
Oecantius nigricornis Walker
Oecanthus niveus (DeGeer)

Mantidae (1)

- Litaneutria minor* Scudder

ISOPTERA (1)

Rhinotermitidae (1)

- Reticulitermes tibialis* Banks

PSOCOPTERA (1)

Psocidae (1)

- Psocidae* No. 1

THYSANOPTERA (12)

Aelolothripidae (2)

- Aelolothrips fasciatus* (L.)
Aelolothripidae No. 1

Thripidae (4)

- Frankliniella tritici* (Fitch)
Thripidae No. 1
Thripidae No. 2
Thripidae No. 3

Phloeothripidae (4)

- Lentothrips mali* (Fitch)
Phloeothripidae No. 1
Phloeothripidae No. 2
Phloeothripidae No. 3

Merothripidae (1)

- Merothripidae* No. 1

Heterothripidae (1)

- Heterothripidae* No. 1

HEMIPTERA (83)

Anthocoridae (3)

- Anthocoris melanocerus* Reuter
Anthocoris musculus (Say)
Orius tristicolor (White)

Miridae (42)

- Adelphocoris lineolatus* (Goeze)
Adelphocoris superbus (Uhler)
Beckocoris laticephalus Knight
Ceratocarpsus fuscicornis Knight
Chlamy datus associatus Uhler
Chlamy datus obliquus (Uhler)

Clivinema villosa Reuter

Coquillettia insignis Uhler

Deraecoris triannulipes Knight

Europiella No. 1

Labopidea sericata Uhler

Lopidea media (Say)

Lygus hesperus Knight

Lygus lineolaris Palisot de Beauvais

Orthotylus althaea Hussey

Orthotylus No. 1

Parthenicus No. 1

Parthenicus No. 2

Parthenicus No. 3

Parthenicus No. 4

Parthenicus No. 5

Parthenicus No. 6

Parthenicus No. 7

Parthenicus No. 8

Phyllini No. 1

Phytocoris No. 1

Phytocoris No. 2

Phytocoris No. 3

Phytocoris No. 4

Pilophorus clavatus (L.)

Plagiognathus No. 1

Plagiognathus No. 2

Polymerus diffusus (Uhler)

Psallus No. 1

Pseudatomoscelis modesta (V.D.)

Slaterocoris flavipes Kelton

Teratocoris discolor Uhler

Trigonotylus americanus Carvalho

Trigonotylus tarsalis (Reuter)

Miridae No. 1

Miridae No. 2

Miridae No. 3

Phymatidae (1)

Phymata fasciata (Gray)

Reduviidae (3)

Sinea diadema (F.)

Sinea undulata Uhler

Zelus socius

Ploiariidae (1)

Ploiaria denticauda M. & M.

Nabidae (1)

Nabis alternatus Parsh

Tingidae (2)

Corythuca immaculata D. & D.

Physatocheila variegata Parsh

Piesmididae (2)

Piesma cinerea Say

Piesma No. 1

SPECIES LIST - OIL SHALE TRACTS

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HEMIPTERA (CONT'D)

Neididae (1)

Jalysus wickhami Van Duzee

Lygaeidae (10)

Crophius disconotus (Say)*Cymus luridus* Stal*Geocoris bullatus* Say*Kleidocerys resedae* (Panzer)*Lygaeus kalmii* Stal*Melanopleurus bistriangularis* (Say)*Nyssius ericae* Schiller*Nyssius monticola* Distant*Sphragisticus nebulosus* (Fallen)*Xyonyssius californicus* Stal

Coreidae (1)

Chelinidea vittiger Uhler

Rhopalidae (4)

Harmostes reflexulus (Say)*Liorhyssus hyalinus* (F.)*Niesthrea sidae* (F.)*Stictopleurus viridicatus* (Uhler)

Coriscidae (1)

Megalotomus 5-spinosus (Say)

Aradidae (1)

Aradus No. 1

Corixidae (1)

Cenorixa utahensis Hungerford

Saldidae (2)

Saldula cornatula Parsh*Saldula pallipes* (F.)

Corimelaenidae (1)

Corimelaena incognita M. & M.

Pentatomidae (7)

Brochymena No. 1*Chlorochroa sayi* Stal*Codophila remota* Horn*Holcostethus abbreviatus* Uhler*Holcostethus limbolarius* (Stal)*Homaemus aeneifrons* (Say)*Thyanta punctiventris* Van Duzee

HOMOPTERA (130)

Cicadidae (1)

Okamagana utahensis Davis

Membracidae (4)

Campylenchia latipes (Say)*Leioscyta ferruginipennis* Goding*Palonica* No. 1*Stictocephala hubalis* (F.)

Cercopidae (3)

Clastoptera delicata Uhler*Clastoptera juniperina* Ball*Clastoptera* No. 1

Cicadellidae (75)

Amblysellus grex Oman*Aceratagallia cinerea* Osborne & Ball*Aceratagallia uhleri* Van Duzee*Aceratagallia* No. 1*Aceratagallia* No. 2*Acinopterus viridis* Ball*Aeusana* No. 1*Aligia oculatea* (Ball)*Aplanus albidus* (Ball)*Balclutha impicta* Van Duzee*Balclutha neglecta* D. & D.*Balclutha punctata* (Thunb.)*Ballana aris* DeLong*Ballana projecta* DeLong*Ceratagallia bigeloviae* (Baker)*Circulifer tenellus* Baker*Colladonus belli* (Uhler)*Colladonus geminatus* (Van Duzee)*Colladonus montanus* (Van Duzee)*Deltocephalini* No. 1*Deltocephalini* No. 2*Deltocephalini* No. 3*Deltocephalus minutus* Van Duzee*Dikrainia carneola* (Stal)*Empoasca alboneura* Gill.*Empoasca exiguae* Ross*Empoasca neaspera* Oman*Empoasca typhlocyboides* Gil. & Baker*Empoasca* No. 1*Empoasca* No. 2*Empoasca* No. 3*Endria inimica* (Say)*Erythroneura aspera* Beamer*Exititianus exitiosus* (Uhler)*Frigartus frigidus* (Ball)*Graphocephala rufimargo* (Walker)*Gyponana* No. 1*Hardya dentata* Osborne & Ball*Hebecephala* No. 1*Idiocerus morosus* Ball*Idiocerus nervatus* Van Duzee*Idiocerus pallidus* Fitch*Idiocerus ramentosus* (Uhler)*Idiocerus rotundens* DeLong & Cole*Idiocerus snowi* Gill. & Ball*Keonella confluens* (Uhler)*Macrosteles fascifrons* (Stal)*Macrosteles snowi* (Dorst)*Macropsis pallida* Bready*Mesamia* No. 1

SPECIES LIST - OIL SHALE TRACTS

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HOMOPTERA (CONT'D)

Cicadellidae (Cont'd)

Mesania No. 2
Norvellina clarivida (Van Duzee)
Norvellina No. 1
Ollarianus No. 1
Opsius stactogalus Fieber
Osbornellus curvatus Beamer
Pachyopsis laetus Uhler
Parabolocratus viridis Uhler
Paraphlepsius lascivius (Ball)
Phlepsanus tumidiatus Crowder
Psammotettix No. 1
Scaphoideus titanus Ball
Scaphytopius acutus (Say)
Scleroracrus plutonius Uhler
Sorhoanus orientalis DeLong & Davidson
Sorhoanus uhleri (Oman)
Stragania grandis Ball
Texananus proximus Crowder
Texananus No. 1
Texananus No. 2
Texananus No. 3
Twiningia blanda (Ball)
Xerophloea peltata (Uhler)
Cicadellidae No. 1
Cicadellidae No. 2

Cixiidae (5)

Cixius No. 1
Oecleus No. 1
Oliarus catus Cald.
Pintalia No. 1
Cixiidae No. 1

Delphacidae (7)

Delphacodes propinquus (Fieber)
Delphacodes No. 1
Pissonotus delicatus Van Duzee
Probelisoides salina (Ball)
Sogatella kolophon (Kirk)
Strobaera tricarinata (Say)
Delphacidae No. 1

Dictyopharidae (3)

Aridia compressa Ball
Scolops sulcipes (Say)
Scolops pallida Uhler

Issidae (2)

Hysteropterum cornutum (Melich)
Thionia producta Van Duzee

Psyllidae (12)

Aphalara artemesia
Aphalara minutissima
Aphalara
Aphalara

Calophya triozae Schwarz

Psylla maculata Crawford

Psylla No. 1

Trioza frontalis Crawford

Trioza No. 1

Trioza No. 2

Triozae No. 1

Psyllidae No. 1

Aleyrodidae (1)

Aleyrodidae No. 1

Aphididae (18)

Aphis medicaginis Koch

Aphis minuta (group) No. 1

Aphis No. 2

Asiphum No. 1

Chaitophorus popullellus G. & P.

Covariella aegyptodii Scopoli

Epameibaphis No. 1

Macrosiphum coweni Hunter

Macrosiphum escalantii Knowlton

Macrosiphum macrosiphum Wilson

Pemphigus No. 1

Penaphini No. 1

Pleotrichophorus longinectarius G. & P.

Pleotrichophorus No. 1

Pleotrichophorus No. 2

Pseudopameibaphis No. 1

Rhopalosiphum No. 1

Uceraphis gilletti Davidson

TRICHOPTERA (6)

Hydropsychidae (2)

Hydropsyche guttata Pictet

Hydropsyche occidentalis Banks

Hydroptilidae (2)

Hydroptilidae No. 1

Hydroptilidae No. 2

Leptoceridae (1)

Nectopsyche albida (Walker)

Lepidostomatidae (1)

Lepidostomatidae No. 1

LEPIDOPTERA (149)

including 40 unidentified
microlepidoptera

Pieridae (5)

Colias eurytheme Boisduval

Euchloe creusa Doubleday & Hewitson

Pieris beckeri Edwards

Pieris protodice Boisduval & LeComte

Pieris sisymbrii Boisduval

Papilionidae (1)

Papilio oregonis Brewster

SPECIES LIST - OIL SHALE TRACTS

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LEPIDOPTERA (CONT'D)

Satyridae (2)

*Cercyonis sthenale**Coenonympha tullia* Muller

Danaidae (1)

Danaus plexippus (L.)

Nymphalidae (7)

Chlosyne acastus Edwards*Euphydryas anicia* (Doubleday)*Euptoieta claudia* Cramer*Limnitis archippus* Cramer*Phyciodes tharos* Drury*Vanessa cardui* (L.)*Vanessa antiopa* (L.)

Riodinidae (1)

Apodemia mormo Felder & Felder

Lycaenidae (3)

Lycaena nivalis Boisduval*Plebejus acmon* (Westwold & Hewitson)*Strymon melinus* Hubner

Hesperiidae (3)

Hesperia juba (Scudder)*Pholisora catullus* (Fabricius)*Pyrgus communis* (Grote)

Arctiidae (2)

Atrachis picta LaFon. & Packer*Taruphiana permaculata* LaFon. & Packer

Sphingidae (1)

Celerio lineata

Noctuidae (53)

Abagrotis barnesi Benjamin*Abagrotis discoidalis* Grote*Abagrotis duaneae* Smith*Abagrotis placida* Grote*Abagrotis variata* Grote*Acontia areli* Strecker*Afotella cylindrica* Grote*Agrotis vetusta* Walker*Apamea auranticolor* Grote*Apamea spaldingi* Smith*Aseptis characta* Grote*Autographa biloba* Stephens*Cataocala arizonae* Grote*Crymodes devastator* Brace*Cucullia dorsalis* Smith*Euxoa atomaris* Grote*Euxoa auxiliaris* Grote*Euxoa catenula* Grote*Euxoa declarata* Walker*Euxoa messeria* Harris*Euxoa olivia* Morrison*Euxoa pallipennis* Smith*Euxoa satiens* Smith*Euxoa septentrionalis* Walker*Euxoa simona* McDunnough*Feltia ducens* Walker*Fishia discors* Grote*Hadenella pergentilis* Grote*Iladeniinae* No. 1*Lacinipolia olivacea* Morrison*Lacinipolia pensilis* Grote*Lacinipolia stricta* Walker*Leucania farcta* Grote*Melipotis jucunda* Hubner*Metalectra bigallis* Smith*Peridroma saucia* Hubner*Platyperigea extima* Walker*Platyperigea meralis* Morrison*Platysenta discistriga* Smith*Protearmanis balanitis* Grote*Protegygia enalaga* McDunnough*Protorthodes utahensis* Smith*Pseudaletia unipuncta* Haworth*Pseudanarta caeca* Dodson*Pseudanarta crocea* Hy. Edwards*Rhynchagrotis exertistigma* Morrison*Schizura acutilinea* Grote*Schinia albifascia* Grote*Schinia arcigera* Guenee*Scotogramma orida* Smith*Scotogramma trifolii* Rottenburg*Synedoida tejonica* Behr*Trichoclea fuscolutea* Smith

Notodontidae (1)

Notodontidae No. 1 (larva)

Olethrentidae (3)

Eucosma cranbitana Welshm.*Eucosma invicta* Welshm.*Eucosma* No. 1

Pyralidae (8)

Dioryctria gulosella Hulst*Dioryctria turnicolella* M. & M.*Loxostege indentalis* Grote*Noctuella rufofascialis* Stephens*Nomophila noctuella* D. & S.*Ommatopteryx ocella* Hawthorn*Pyralidae* No. 1*Pyralidae* No. 2

Pyromorphidae (1)

Harrisina brillians Barnes & McDunnough

Ctenuchidae (1)

Lycomorpha splendens Barnes & McDunnough

SPECIES LIST - OIL SHALE TRACTS

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LEPIDOPTERA (CONT'D)

Geometridae (13)

Chlorochlamys appellaria Pears
Dysstroma ethela Hulst
Eupithecia multistrigata Hulst
Horizma intestinata Guerin
Perizoma custodiata Guerin
Prochoerodes truxaliata Guerin
Prorella opinata Pears
Semiothisa curvata Grote
Semiothisa decorata Grossb
Semiothisa irrorata Packard
Semiothisa nubiculata Packard
Semiothisa subminiata Packard
Synchlora liquoraria Guerin

Alucitidae (1)

Alucita huebneri (Wallen)

Sessiidae (3)

Aegeria tibialis
Aegeria No. 1
Sessiidae No. 1

Saturniidae (1)

Pseudohazis No. 1

NEUROPTERA (14)

Raphididae (1)

Agulla No. 1

Coniopterygidae (3)

Coniopterygidae No.1
Coniopterygidae No.2
Coniopterygidae No.3

Hemerobiidae (4)

Hemerbius No. 1
Micromus No. 1
Sympherobius No. 1
Sympherobius No. 2

Berothidae (1)

Lomomyia No. 1

Chrysopidae (3)

Chrysopa No. 1
Chrysopa No. 2
Chrysopa No. 3

Myrmeleontidae (2)

Hesperoleon No. 1
Hesperoleon No. 2

COLEOPTERA (281)

Carabidae (24)

Agonoderus obligulus Casey
Amara (Curtonotus) No. 1
Badister No. 1
Bembidion obscurellum Mots
Bembidion rupicola Kirby

Bembidion No. 1

Bembidion No. 2

Bembidion No. 3

Bembidion No. 4

Bembidion No. 5

Bembidion No. 6

Bembidion No. 7

Chlaenius No. 1

Clivina No. 1

Dyschirius No. 1

Elapropus No. 1

Harpalus No. 1

Harpalus No. 2

Lebia viridis Say

Lebia No. 1

Lebia No. 2

Foecilus lucublandus Say

Pseudaptinus No. 1

Pterostichus adstrictus Eschscholtz

Gyrinidae (1)

Gyrinus No. 1

Dytiscidae (4)

Deroneoctes striatellus Lec.

Hygrotus sellatus Lec.

Liodesus affinis (Say)

Ochthebius lineatus Lec.

Cicindellidae (3)

Cicindella pusilla imperfecta Lec.

Cicindella repanda Dejean

Cicindella tranquebarica uintana Casey

Histeridae (2)

Paromalus aequalis Say

Saprinus lugens Er.

Hydrophilidae (7)

Berosus fraternus LeConte

Enochrus horni Leech

Helophorus leechi McCorkle

Laccobius agilis Rand.

Paracymus confusus Woold

Sphaeridium lunatum Fabricius

Tropisternus lateralis Fabricius

Limnobiidae (1)

Limnobiidae No. 1

Ptiliidae (1)

Nephanes No. 1

Silphidae (2)

Microphorus No. 1

Silpha lapponica

Leiodidae (1)

Leiodidae No. 1

SPECIES LIST - OIL SHALE TRACTS

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COLEOPTERA (CONT'D)

Staphylinidae (28)

Aleochara bipunctulata L.
Aleochara bimaculata Gray
Aleocharinae No. 1
Aleocharinae No. 2
Aleocharinae No. 3 and No. 4
Astenus No. 1
Bedius No. 1
Bedius No. 2
Bedius No. 3
Bedius No. 4
Bedius No. 5
Carpelimus No. 1
Carpelimus No. 2
Carpelimus No. 3
Gabrieus No. 1
Lobrathium No. 1
Neobisnius No. 1
Oxytelus No. 1
Quedius No. 1
Scopaeus No. 1
Scopaeus No. 2
Tachyporus No. 1
Tachyporus No. 2
Thinobius No. 1
Xantholininae No. 1
Xantholininae No. 2
Staphylinidae No. 1

Pselaphidae (1)

Reichenbachia No. 1

Cantharidae (3)

Chauliognathus basalis LeConte
Podabrus No. 1
Silis difficilis LeConte

Lampyridae (1)

Pyropyga No. 1

Dermestidae (5)

Anthrenus lepidus LeConte
Cryptorhynchus uteanus Casey
Dermestes caninus Germar
Dermestes fasciatus LeConte
Trogoderma variabile Ballion

Melyridae (9)

Anthocomus thevenetii
Anthocomus No. 1
Collops bipunctatus
Collops utahensis Schaffer
Collops vitatus Say
Collops No. 1
Collops No. 2
Tanaops No. 1
Tanaops No. 2

Dasytidae (9)

Amecocerus luteipes LeConte
Eudastes No. 1
Listrus interruptus
Mecomyctes No. 1
Mecomyctes No. 2
Mecomyctes No. 3
Mecomyctes No. 4
Trichochrous No. 1
Vectura No. 1

Trogositidae (1)

Tenebroides No. 1

Cleridae (5)

Cymatodera sobara Barr
Hydnocera No. 1
Hydnocera No. 2
Trichodes ornatus Say
Trichodes simulator Horn

Elateridae (3)

Elateridae No. 1
Laeon No. 1
Ludius pudicus Brown

Buprestidae (4)

Acmacodera variegata LeConte
Agrilus malvastri Fisher
Agrilus No. 1
Chrysobothris No. 1

Heteroceridae (3)

Heteroceridae No. 1
Lautermarius parrotus Pacheco
Neoheterocerus gnatho (LeConte)

Cryptophagidae (2)

Cryptophagidae No. 1
Cryptophagidae No. 2

Phalacridae (5)

Olibrus rufipes (?) LeConte
Phalacrus penicillatus Say
Phalacrus No. 1
Phalacrus No. 2
Stilbus No. 1

Nitidulidae (5)

Brachypsterolus pulicarius (L.)
Carpophilus lugubris Mur.
Carpophilus pallipennis Say
Cybocephalus No. 1
Meligethes dauricus Mots.

Lathridiidae (1)

Melanophthalma No. 1

Coccinellidae (18)

Brumoides septentrionis Weise
Coccinella difficilis Crotch
Coccinella novemnotata Herbst

SPECIES LIST - OIL SHALE TRACTS

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COLEOPTERA (CONT'D)

Coccinellidae (Cont'd)

Coccinella transversoguttata
Coccinella trifasciata perplexa Muls.
Hippodamia apicalis Casey
Hippodamia convergens
Hippodamia quinquesignata uteana Casey
Hippodamia tredecimpunctata tibialis (Say)
Hyperaspis bensonica Casey
Hyperaspis dissoluta Crotch
Hyperaspis lateralis Mulsant
Hyperaspis taeniata LeConte
Hyperaspis No. 1
Psyllobora 20-maculata (Say)
Scymnus ardello Horn
Scymnus nugator Casey
Scymnus renoicus Casey

Colydiidae (2)

Bitoma No. 1
Synchita No. 1

Cerylonidae (1)

Cerylon castaneum (Say)

Mycetophagidae (2)

Mycetophagus distinctus Hatch
Mycetophagus quadriguttatus Muller

Anthicidae (8)

Anthicus ephippium LaFerte
Anthicus hastatus Casey
Ishyropalpus nitidulus LeConte
Ishyropalpus turgidicollis Casey
Notoxus marginatus LeConte
Notoxus serratus LeConte
Thiccanus mimus Casey
Tomoderus impressulus (?) Casey

Oedemeridae (3)

Eumecomera obscura (LeConte)
Oxaxis sericea Horn
Xanthochroina bicolor (LeConte)

Meloidae (9)

Epicauta fabricii LeConte
Epicauta ferruginea Say
Epicauta normalis Werner
Epicauta puncticollis Mann
Gnathium No. 1
Hornia minutipennis
Nemognatha immaculata
Nemognatha lurida
Zonitis flavida

Rhipiphoridae (1)

Macrosiagon cruentum

Mordellidae (6)

Anaspis No. 1
Anaspidinae No. 1
Anaspidinae No. 2
Mordellistena No. 1
Mordellistena No. 2
Mordellidae No. 1

Alleculidae (1)

Telesicles cordatus

Tenebrionidae (21)

Eolitotherus cornutus Panzer
Bothrotes plumbeus LeConte
Bothrotes scutatus
Chilometopon No. 1
Cnemeplatia sericata Horn
Coelocnemis sulcata Casey
Cynaesus angustus LeConte
Eleodes extricata Say
Eleodes hispilabris sculptilis Blatch
Eleodes humeralis LeConte
Eleodes omissa LeConte
Eleodes pilosa Horn
Eleodes pimmelioides Mann
Eleodes No. 1
Embaphion elongatum Horn
Glytasis crenicollis Casey
Lobometopon fusiforme Casey
Platydemia americana
Tribolium
Trogloclerus costatus tuberculatus Blais
Tenebrionidae No. 1

Melandryidae (1)

Allopoda No. 1

Anobiidae (1)

Anobiidae No. 1

Ptinidae (1)

Ptinus No. 1

Scarabaeidae (12)

Aphodius aculeatus Robinson
Aphodius denticulatus Haldeman
Aphodius fimetarius (L.)
Aphodius granarius (L.)
Aphodius vittatus Say
Aphodius No. 1
Aphodius No. 2
Bothynus gibbosus (DeGeer)
Cremastocheilus crinitus LeConte
Diploctaxis haydeni LeConte

SPECIES LIST - OIL SHALE TRACTS

COLEOPTERA (CONT'D)

Scarabaeidae (CONT'D)

Diplotaxis

Paracotalpa granicollis Haldeman

Cerambycidae (4)

Crossideus corallinus

Methia mormona

Molorchus bimaculata

Tetraops No. 1

Chrysomelidae (28)

Calomicrus No. 1

Chaetocnema elongatula (?) Crotch

crepidodera nana Say

Cryptocephalus confluentus Say

Diachus auratus Fabricius

Disonychia latiovittata Hatch

Glyptina cerina (LeConte)

Longitarsus nitidellus Cockerell

Monoxia angularis

Monoxia elegans Blake

Monoxia obesula Blake

Monoxia puberula (?) Blake

Monoxia sordida LeConte

Pachybrachys bivittatus (Say)

Pachybrachys croftus (?) Bowditch

Pachybrachys signatus Bowditch

Pachybrachys No. 1

Paria quadriguttata (LeConte)

Phaedon virigus Melsh

Phyllotreta chalybeipennis (?)

Phyllotreta No. 1

Psyllioides No. 1

Pyrrehalta luteola Muller

Pyrrehalta No. 1

Saxinis saucia LeConte

Systema gracilentia (?) Blake

Trirhabda No. 1

Chrysomelidae No. 1

Bruchidae (3)

Acanthoscelides aureolus (Horn)

Acanthoscelides collusus (Fallen)

Acanthoscelides No. 1

Curculionidae (25)

About 25 spp. still on loan

Platypodidae (1)

Platypus No. 1

Scolytidae (1)

Phloeosinus No. 1

Stylopidae (3)

Halictophagus No. 1

Halictophagus No. 2

Pseudoxenos No. 1

DIPTERA (647)

Tipulidae (8)

Empedomorpha empedoides (Alexandar)

Erioptera cana (Walker)

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Erioptera No. 1

Limonia venusta (Bergroth)

Tipula barbata Doane

Tipula calcarata Doane

Tipula No. 1

Tipula No. 2

Psychodidae (3)

Lutzimyia oppidiana Dampf

Psychodidae No. 1

Psychodidae No. 2

Culicidae (5)

Aedes melanimon Dyar

Aedes nigromaculus (Ludlow)

Aedes vexans (Meigen)

Culex tarsalis Coquillett

Culiseta inornata (Williston)

Ceratopogonidae (20)

Atrichopogon fuscus (Coquillett)

Atrichopogon No. 1

Bezzia setulosa (Loew)

Culicoides denningi Foote & Pratt

Culicoides hieroglyphicus Malloch

Culicoides nr. palmerae

Culicoides variipennis Coquillett

Culicoides (Selfia) No. 1

Culicoides (Selfia) No. 2

Dasyhelea grisea (Coquillett)

Dasyhelea mutabilis (Coquillett)

Dasyhelea No. 1

Dasyhelea No. 2

Forcipomyia brevipennis (Macquaert)

Forcipomyia monilicornis (Coquillett)

Forcipomyia squamipes (Coquillett)

Forcipomyia No. 1

Leptoconops nr. kerteszi

Leptoconops torrens (Townsend)

Palpomyia subaspera (Coquillett)

Probezzia bottimeri Wirth

Ceratopogonidae No. 1

Chironomidae (26)

Chironomus No. 1

Chironomus No. 2

Chironomus No. 3

Chironomus No. 4

Chironomus No. 5

Cricotopus No. 1

Cricotopus No. 2

Cricotopus No. 3

Cryptochironomus No. 1

Diamesinae No. 1

Hydrobaenus No. 1

Hydrobaenus No. 2

SPECIES LIST - OIL SHALE TRACTS

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DIPTERA (CONT'D)

Chironomidae (Cont'd)

Hydrobaenus No. 3

Hydrobaenus No. 4

Hydrobaenus No. 5

Hydrobaenus No. 6

Hydrobaenus No. 7

Hydrobaenus No. 8

Hydrobaenus No. 9

Microtendipes No. 1

Microtendipes No. 2

Paratendipes No. 1

Polypedilum No. 1

Tanypodinae No. 1

Tanypodinae No. 2

Tanypodinae No. 3

Simuliidae (2)

Simulium griseum Coquillett

Simulium No. 1

Mycetophilidae (6)

Acnemia No. 1

Allodia No. 1

Docosia No. 1

Exechia No. 1

Leia No. 1

Myceomya No. 1

Sciaridae (6)

Bradysia No. 1

Bradysia No. 2

Bradysia No. 3

Bradysia No. 4

Bradysia No. 5

Sciara No. 1

Scatopsidae (3)

Scatopsidae No. 1

Scatopsidae No. 2

Scatopsidae No. 3

Cecidomyiidae (16)

Asphondylia No. 1

Cecidomyiidi No. 1

Cecidomyiidi No. 2

Clinodiplosis No. 1

Dasineura No. 1

Ledomia No. 1

Lostremia No. 1

Lostremia No. 2

Lostremia No. 3

Mayetiola No. 1

Neolasiophora No. 1

Neolasiophora No. 2

Porricondyla No. 1

Porricondyla No. 2

Rhopzomyia No. 1

Rhopzomyia No. 2

Stratiomyidae (4)

Nemotelus canadensis Loew

Nemotelus communis Hanson

Nemotelus politus Hanson

Sargus cuprarius (L.)

Tabanidae (2)

Apantolastes comastes Williston

Silvius quadrivittatus Say

Rhagionidae (1)

Chrysopilus testaceipes

Hilarimorphidae (1)

Hilarimorpha No. 1

Therevidae (8)

Apsilcephala longistyla Kroger

Psilocephala aldrichi Coquillett

Psilocephala coloradensis James

Psilocephala No. 1

Psilocephala No. 2

Psilocephala No. 3

Thereva fucata Loew

Thereva johnsoni Coquillett

Scenopinidae (2)

Scenopinidae No. 1

Scenopinidae No. 2

Mydidae (1)

Mydas santhopterus Loew

Asilidae (22)

Asilus compositus Hine

Asilus lumbipilosa Adison

Asilus mesae Tucker

Asilus tunpanganus (?) Bell

Asilus vesus Hine

Efferia No. 1

Efferia No. 2

Efferia No. 3

Holopogon albiplonus Curran

Holopogon atrifrons Cole

Holopogon phaenotus Loew

Holopogon No. 1

Holopogon No. 2

Leptogaster No. 1

Leptogaster No. 2

SPECIES LIST - OIL SHALE TRACTS

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DIPTERA (CONT'D)

Asilidae (Cont'd)

Leptogaster No. 3
Leptogaster No. 4
Mallophorina guildiana Williston
Proctocanthus nearno Townsend
Promachus aldrichii Hine
Stichopogon trifasciatus Say
Wilcoxia painteri Wilcox

Bombyliidae (64)

Anthrax irroratus Say
Anthrax limatulus
Anthrax plesia Curran
Aphoebantus No. 1
Bombylius No. 1
Bombylius No. 2
Dipalta serpentina Osten Sacken
Epacmus No. 1
Exoprosopa calyptera Say
Geron No. 1
Geron No. 2
Geron No. 3
Geron No. 4
Geron No. 5

Mythicomya atra Cresson

Mythicomya No. 1
Mythicomya No. 2
Mythicomya No. 3
Mythicomya No. 4
Mythicomya No. 5
Mythicomya No. 6
Mythicomya No. 7
Mythicomya No. 8
Mythicomya No. 9
Mythicomya No. 10
Mythicomya No. 11
Mythicomya No. 12
Mythicomya No. 13
Mythicomya No. 14
Mythicomya No. 15
Mythicomya No. 16
Mythicomya No. 17

Neachreotrichus No. 1

Oligodranes No. 1

Oligodranes No. 2

Oligodranes No. 3

Phthiria sulphurea Loew

Phthiria No. 1

Phthiria No. 2

Phthiria No. 3

Phthiria No. 4

Phthiria No. 5

Phthiria No. 6

Phthiria No. 7

Phthiria No. 8

Poecilanthrax signatipennis (Cole)

Poecilanthrax willistoni (Coquillett)

Prorates No. 1

Systoechus vulgaris Loew

Toxophora virgata Osten Sacken

Villa capra Coquillett

Villa lateralis Say

Villa lepidota (Osten Sacken)

Villa morio

Villa sinuosa Wiedeman

Villa syrtis Coquillett

Villa No. 1

Villa No. 2

Villa No. 3

Villa No. 4

Villa No. 5

Villa No. 6

Villa No. 7

Empididae (18)

Drapetis No. 1

Drapetis No. 2

Drapetis No. 3

Empis No. 1

Empis No. 2

Empis No. 3

Hemerodromia

Hilara No. 1

Hilara No. 2

Neoplasta No. 1

Platypalpus No. 1

Platypalpus No. 2

Platypalpus No. 3

Empididae No. 1

Empididae

Empididae

Empididae

Dolichopodidae

Argyra robusta

Asyndetus latus

Asyndetus texanus

Campsicnemus philoctetes

Chrysotimus

Chrysotus palpiger

Chrysotus picticornis

Diaphorus aldrichi

DIPTERA (CONT'D)

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Dolichopodidae (Cont'd)

- Diaphorus fuscus* VanDuzee
Dolichopus acuminatus Loew
Dolichopus afflictus Osten Sacken
Dolichopus appendiculatus VanDuzee
Dolichopus conspectus VanDuzee
Dolichopus coquillettii Aldrich
Dolichopus cuprinus Wiedeman
Dolichopus jugalis Turner
Dolichopus oecordatus Aldrich
Dolichopus ramifer Loew
Hercostomus cryptus Harmston & Knowlton
Hercostomus setosus VanDuzee
Medetera vales Loew
Parasyntormon classicus Harm. & Knowl.
Parasyntormon hinnulus Wheeler
Pelastoneurus vagans Loew
Rhaphium effilatum Wheeler
Sympyenus No. 1
Thinophilus depressus VanDuzee
Thrypticus fraterculus Wheeler
- Lonchopteridae (1)
Lonchoptera No. 1
- Phoridae (7)
Phoridae No. 1
Phoridae No. 2
Phoridae No. 3
Phoridae No. 4
Phoridae No. 5
Phoridae No. 6
Phoridae No. 7
- Pipunculidae (6)
Pipunculidae No. 1
Pipunculidae No. 2
Pipunculidae No. 3
Pipunculidae No. 4
Pipunculidae No. 5
Pipunculidae No. 6
- Syrphidae (28)
Allograpta obliqua Say
Asemosyrphus polygrammus Loew
Bacca lemur Osten Sacken
Ceriana tridens Loew
Chrysotoxum integre Williston
Chrysotoxum ventricosum Loew
Eristalis stipitator Osten Sacken
Eristalis tenax (L.)
Eumerus strigatus Fallen
Eupeodes volucris Osten Sacken
Halophila latifrons Loew
Melanostoma No. 1
Melanostoma No. 2
Mesogramma marginata Say
Metasyrphus No. 1
Neocnemodon No. 1
Paragus bicolor (F.)
Paragus tibialis Fallen
Platycheirus No. 1
Scaeva pyrastris (L.)
Sphaerophoria No. 1
Syrphus No. 1
Syrphid No. 1
Tropidea quadrata Say
Volucella caudata Curran
Volucella saturata Osten Sacken
Xylota flavitibialis Bigot
Xylota No. 1
- Conopidae (7)
Physocephala texana Williston
Robertsonomyia parva VanDuzee
Thecophora nigripes Camras
Thecophora propinqua Adams
Zodion americanum Weideman
Zodion cinereiventris VanDuzee
Zodion fulvifrons Say
- Otitidae (12)
Ceroxys latiuscula Loew
Euxesta nitidiventris (Loew)
Euxesta No. 1
Meliera canus Loew
Oedopa capito Loew
Otites michiganus Steyskal
Otites pyrrocephala Loew
Paroedopa punctigera Coquillett
Physiphora demandata (F.)
Tetanops myopaeformis Roder
Tritoxa pollinosa Cole
Haigia nevadana Steyskal
- Tephritidae (19)
Aciurina ferruginea Doane
Euaresta aequalis Loew
Euaresta tapetis Coquillett
Euarestoides acutangulus Thom.
Eutreta diana (Osten Sacken)
Neaspilota No. 1
Oxya aterrima Doane
Oxya palpalis
Oxya utahensis Quis.
Paracantha cultaris Coquillett
Paraterellia No. 1
Paroxya clathrata Loew

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DIPTERA (CONT'D)

Tephritidae (Cont'd)

- Paroxyna* No. 1
- Procecidochares minuta* (Snow)
- Trupanea bisetosa* Coquillett
- Trupanea jonesi* Curran
- Trupanea nigricornis* Coquillett
- Urophora timberlakei* Blanch & Foote

Sepsidae (2)

- Sepsis neocynipsea* M. & S.
- Sepsis biflexuosa* M. & S.

Sciomyzidae (2)

- Pherbellia humilis* (Loew)
- Pherbellia nana* (Fallen)

Lauxaniidae (3)

- Homoneura* No. 1
- Mnettia* No. 1
- Mnettia* No. 2

Chamaemyiidae (5)

- Chamaemyia juncorum* (Fallen)
- Leucopis* No. 1
- Leucopis* No. 2
- Leucopis* No. 3
- Pseudodidinia varipes* Coquillett

Lonchacididae (3)

- Dasiops* No. 1
- Dasiops* No. 2
- Lonchaea* No. 1

Sphaeroceridae (3)

- Leptocera* No. 1
- Leptocera* No. 2
- Leptocera* No. 3

Tethinidae (4)

- Pelomyia coronata* Loew
- Pelomyiella mallochii* (Sturt.)
- Pelomyiella melanderi* Sturt
- Tethinus* No. 1

Milichiidae (8)

- Desmometopa tarsalis* Loew
- Eusiphona mira* Coquillett
- Leptomotopa halteralis* Coquillett
- Leptomotopa lateralis* Meigen
- Madiza glabra* Fallen
- Milichia* No. 1
- Milichia* No. 2
- Milichiella arcuata* (Loew)

Carnidae (4)

- Hemeromyia obscura* Coquillett
- Hemeromyia washingtona* Melander
- Meoneura polita* Sabrosky
- Meoneura* No. 1

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Chyromyidae (1)

- Aphanisoma frontatum* Wheeler

Psilidae (1)

- Psila washingtona* Melander

Micropezidae (1)

- Micropeza* No. 1

Ephydriidae (34)

- Allotrichoma* No. 1
- Allotrichoma* No. 2
- Athyroglossa ordinata* Becker
- Atissa pygmaea* (Halid.)
- Discocerina obscura* (Fallen)
- Discocerina* No. 1
- Ditrichophora valens* Cresson
- Ephydra cinerea* Jones
- Ephydra macellaria* Egg.
- Ephydra packardii* Wirth
- Hyadina pruinosa* Cresson
- Hydrellia* No. 1
- Hydrellia* No. 2
- Hydrochasma buccatum* (Cresson)
- Illythea* No. 1
- Lamprosecatella dichæta* (Loew)
- Lytogaster abdominalis* (Stenhammer)
- Ilosillus tibialis* Cresson
- Notiphila decoris* Williston
- Notiphila macrochaeta* Loew
- Notiphila olivacea* (Cresson)
- Ochthera mantis* Williston
- Paracoenia bisetosa* (Coquillett)
- Paracoenia trispinosa* (Coquillett)
- Paracoenia turbida* Curran
- Parydra parasocia* Clausen
- Pelina truncatula* Loew
- Pelina* No. 1
- Philygria debilis* Loew
- Psilopa compta* Meigen
- Psilopa olga* Cresson
- Scatella laxa* Cresson
- Scatella paludum* Meigen
- Scatella stagnalis* (Fallen)

Drosophilidae (4)

- Drosophila novamexicana* Patton
- Drosophila* No. 1
- Scaptomyza flaveola* (Meigen)
- Scaptomyza pallida* (Zetterstedt)

Chloropidae (41)

- Aphanotrigonum* No. 1
- Cetema* No. 1

DIPTERA (CONT'D)

Chloropidae (Cont'd)

Chlorops lituratus Adams
Chlorops No. 1
Chlorops No. 2
Conioscinella No. 1
Diptotoxa inclinata (?) Becker
Diptotoxa recurva Adams
Diptotoxa versicolor (?) Loew
Elachiptera nigriceps (Loew)
Eribolus nana (Zetterstedt)
Fiebrigella No. 1
Gaurax No. 1
Hapleginella conicola Greene
Hippelates montanus Sabrosky
Hippelates pusio Loew
Hippelates No. 1
Lasiopleura No. 1
Lasiosina approximatonerva (Zett.)
Lasiosina similis (Malloch)
Meromyza communis Fed.
Meromyza No. 1
Ocella parva (Adams)
Ocella provocans Becker
Ocella punctifrons Becker
Ocella No. 1
Ocella No. 2
Oscinella coxendrix (Fitch)
Oscinella Frit (L.)
Oscinella hesperia Sabrosky
Oscinella virgata Coquillett
Oscinella No. 1
Pholeomyia nr. indecora (Loew)
Siphonella neglecta Becker
Siphonella nigripalpis Malloch
Siphonella No. 1
Thaumatomyia appropinqua Adams
Thaumatomyia glabra
Thaumatomyia pulla Adams
Thaumatomyia pullipes (Coquillett)
Thaumatomyia rubida (Coquillett)

Agromyzidae (29)

Agromyza albipennis Macquaert
Agromyza No. 1
Agromyza No. 2
Calycomyza No. 1
Calycomyza No. 2
Calycomyza No. 3
Cerodontha dorsalis (Loew)
Cerodontha occidentalis Sehgal

Liriomyza No. 1
Liriomyza No. 2
Liriomyza No. 3
Liriomyza No. 4
Liriomyza No. 5
Liriomyza No. 6
Liriomyza No. 7
Liriomyza No. 8
Melanagromyza virens (?) Loew
Melanagromyza No. 1
Melanagromyza No. 2
Napomyza No. 1
Ophomyia No. 1
Ophomyia No. 2
Ophomyia No. 3
Ophomyia No. 4
Phytagromyza No. 1
Phytagromyza No. 2
Phytagromyza No. 3
Phytagromyza No. 4
Phytoliriomyza arctica Lundberg

Trixoscelidae (7)
Spilochroa punctipennis Melander
Trixoscelis frontalis Fallen
Trixoscelis sagulata Melander
Trixoscelis No. 1
Trixoscelis No. 2
Trixoscelis No. 3
Zagonia flavicornis Melander

Anthomyzidae (2)
Anthomyza gracilis Fallen
Anthomyza No. 1

Asteiidae (3)
Asteia multipunctata Sabrosky
Astiosoma No. 1
Phlebosotera setipalpis Sabrosky

Anthomyiidae (26)
Calythea micropteryz Loew
Cordilura latifrons Loew
Hydrophora divisa (Meigen)
Hylemya cinerella Fallen
Hylemya concordia Huckett
Hylemya neomexicana Malloch
Hylemya normalis Malloch
Hylemya platura Meigen
Hylemya setiventris (?) Gr.
Leucophora cinerea Rob.-Desvoidy
Leucophora maculata (Stein)
Leucophora No. 1

DIPTERA (CONT'D)

Anthomyiidae (Cont'd)

Pegomya acutipennis Malloch*Pegomya* No. 1*Pegomya* No. 2*Pegomya* No. 3*Pegomya* No. 4*Pegomya* No. 5*Pegomya* No. 6*Pseudoleria* No. 1*Scatophaga stercoraria* (L.)

Anthomyiidae No. 1

Anthomyiidae No. 2

Anthomyiidae No. 3

Anthomyiidae No. 4

Anthomyiidae No. 5

Muscidae (25)

Coenosia No. 1*Fannia canicularis* (L.)*Fannia canicularis* No. 1*Haematobia irritans* (L.)*Helina nigripennis* (Walker)*Helina troene* (Walker)*Helina* No. 1*Hydrototaea militaris* (Meigen)*Limosia* No. 1*Limosia* No. 2*Lispe nasoni* Stein*Lispe polita* Coquillett*Lispe sociabilis* Loew*Musca domestica* L.*Musca autumnalis**Muscina assimilis* (Fallen)*Muscina fulvacrura* Snyder*Myospila meditabunda* (Fabricius)*Oribellia caesarion* (Meigen)*Quadrulania latifolia* (Rob.-Desvoidy)*Schoenomyza dorsalis* Loew*Spilogona argentiventris* (Malloch)*Spilogona* No. 1*Tetramerina parvimaculata* (Stein)*Tetramerina* nr. *unica* Stein

Calliphoridae (8)

Bufolucilia hetuna (Stein)*Bufolucilia silvarum* (Meigen)*Calliphora coloradensis* Hough*Calliphora vicina* Rob.-Desvoidy*Cynomyopsis cadaverina* (Rob.-Desvoidy)*Eucalliphora lilaea* Walker*Phaenicia sericata* (Meigen)*Phormia regina* (Meigen)

Sarcophagidae (30)

Amobia floridensis Townsend*Blaesoxipha bishoppi* Aldrich*Blaesoxipha eleodis* (Aldrich)*Blaesoxipha* nr. *garia* (Aldrich)*Blaesoxipha hunteri* (Hough)*Blaesoxipha opifera* (Coquillett)*Blaesoxipha reversa* (Aldrich)*Eumacronychia montana* Allen*Gymnomosopa pallida* Allen*Helicobia repax* Walker*Hilarella hilarella* Zetterstedt*Metopia argyrocephala* (Meigen)*Opsidia oflata* Townsend*Phrosinella pilosifrons* Allen*Ptychoneura aristalis* (Coquillett)*Ravinia inermieri* (Rob.-Desvoidy)*Ravinia planifrons* (Aldrich)*Ravinia querula* (Walker)*Sarcophaga bullata* Parker*Sarcophaga davidsoni* Coquillett*Sarcophaga* No. 1*Sarcophaga* No. 2*Senotainia flavicornis* Townsend*Senotainia rubriventris* Macquaert*Senotainia trilineata* (Wulp)*Senotainia* nr. *trilineata* (Wulp)*Sphenometopa tergata* (Coquillett)*Taxigramma heteroneura* (Meigen)*Wohlfahrtia vigil* (Walker)*Sarcophagidae* No. 1

Tachinidae (75)

Acemya No. 1*Aeroglossa finitima* (Snow)*Aplomya confusionis* Sellers*Bonnetia conita* (Fallen)*Catagoniopsis* No. 1*Ceracia dentata* (Coquillett)*Chaetogaedia townsendi* Sabr. & Arn.*Chaetonodexodes vandenvulpi* (Townsend)*Clausicella setigera* (Coquillett)*Cylindromyia californica* (Bigot)*Deopalpus hirsutus* Townsend*Drepanoglossa lucens* Townsend*Elfia usitata* (Coquillett)*Elfia* No. 1*Elfia* No. 2*Elfia* No. 3*Elfia* No. 4*Eryciini* No. 1

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DIPTERA (CONT'D)

Tachinidae (Cont'd)

Exorista No. 1
Exoristoides johnsoni Coquillett
Gonia No. 1
Gonia No. 2
Gonia No. 3
Gonia No. 4
Goniochaeta plagioides Townsend
Gymnosoma filiola Loew
Gymnosoma fuliginosus R.D.
Gymnosoma occidentale Curran
Hyalomya aldrichi Townsend
Leucostoma simplex (Fallen)
Lixophaga No. 1
Madremyia saundersi Williston
Medina barbata Coquillett
Meigenielloides cinereus Townsend
Metopotachina No. 1
Metopotachina No. 2
Microchaetina nr. *vallida* Townsend
Microchaetina No. 1
Micromintha melania Townsend
Microphthalma disjuncta Wiedeman
Nowickia No. 1
Nowickia No. 2
Nowickia No. 3
Oxygnops anthracinus (Bigot)
Paradidyma obliqua Reinhard
Paradidyma nr. *retracta* Reinhard
Paradidyma singularis Townsend
Paradidyma No. 1
Pararchytes decius (Walker)
Peleteria No. 1
Peleteria No. 2
Periscepsia cinerosa (Coquillett)
Periscepsia helymus (Walker)
Periscepsia laevibata Wulp
Phantasiomyia atripes (Coquillett)
Phantasiomyia gracilis Townsend
Procatharosia No. 1
Promasypha confusa (Aldrich)
Pseudoperichaeta erecta (Coquillett)
Reinhardiana petiolata (Townsend)
Schizactia vitinervis (Thompson)
Sitophaga nr. *lateralis* (Curran)
Sitophaga nr. *mutabilis* (Coquillett)
Sphallanzania hebes (Fallen)
Spathidexia No. 1
Spoggosia No. 1
Stomatomya parvipalpis Williston

Voria ruralis (Fallen)

Xanthomelanodes californica Townsend

Tachinidae No. 1

Tachinidae No. 2

Tachinidae No. 3

Tachinidae No. 4

Tachinidae No. 5

HYMENOPTERA (809)

Tenthredinidae (1)

Dolerus aprili Norton

Braconidae (88)

Agathis atripes (Cress.)

Agathis brevicornis Mues.

Agathis gibbosa Say

Agathis nigripes (Cress.)

Agathis No. 1

Agathis No. 2

Agathis No. 3

Agathis No. 4

Apanteles No. 1

Apanteles No. 2

Apanteles No. 3

Apanteles No. 4

Apanteles No. 5

Apanteles No. 6

Apanteles No. 7

Aphidius No. 1

Aphidius No. 2

Blacus No. 1

Brachystropha No. 1

Brachystropha No. 2

Bracon erucarum Cushman

Bracon gelechiae Ashm.

Bracon hyslopi (Vier)

Bracon meromyza Gahan

Bracon No. 1

Bracon No. 2

Bracon No. 3

Bracon No. 4

Cordiobiles rubicundus Mav

Chelonus (Chelonus) sericeus Say

Chelonus No. 1

Chelonus No. 2

Chelonus No. 3

Chelonus No. 4

Chelonus (Microchelonus) hurdi (?) McConke

Chelonus No. 1

Chelonus No. 2

Chelonus No. 3

Chelonus No. 4

HYMENOPTERA (CONT.)

Braconidae (Cont'd)

Chelonus No. 5
Chelonus No. 6
Chorebus No. 1
Choribidella No. 1
Coelonidea No. 1
Crassomicrodus fulvescens (Cress.)
Cremnops californicus (Murr.)
Elasmosoma No. 1
Ghaptodon nepticulae (Roh.)
Heterospilus No. 1
Hormius No. 1
Hormius No. 2
Hormius No. 3
Hormius No. 4
Iphiaulax No. 1
Iphiaulax No. 2
Iphiaulax No. 3
Lysaphidius ramithyrus Smith
Lysiphlebus testaceipes (Cress.)
Lysiphlebus utahensis (Smith)
Macrocentrus incompletus Mues.
Macrocentrus iridescens French
Macrocentrus No. 1
Metacoelus leviventris (Wesm.)
Microctonus oleodis Vier.
Microgaster No. 1
Microplitis croceipes (Cress.)
Microplitis varicolor Vier.
Microtypus No. 1
Microtypus No. 2
Microtypus No. 3
Mirax No. 1
Mirax No. 2
Opius chavaneanus (?) Fischer
Opius irregularis (?) (Wesm.)
Opius No. 1
Opius No. 2
Orgilus impiger Mues.
Orthostigma No. 1
Parahormius pallidipes (Ashm.)
Thaenonotus cressoni M. & W.
Rhytipolis No. 1
Rogas scrutator (Say)
Rogas No. 1
Tetrasphaeropyx No. 1
Trioxys bonnevillensis Smith
Braconidae No. 1
Braconidae No. 2
Braconidae No. 3

Ichneumonidae (59)

Aerolytina No. 1
Anomalon No. 1
Anomalon No. 2
Atractodes No. 1
Barichneumon No. 1
Bathyplectes curculionis (Thom.)
Buathra laborator (D.T.)
Campoletis No. 1
Campoletis No. 2
Campoletis No. 3
Campoplex No. 1 and No. 2
Campoplex No. 3
Cassinaria nr. *linenitidis*
Coccygomimus No. 1
Compsocryptus No. 1
Compsocryptus No. 2
Cryptus albitarsis Cress.
Cryptus minimus Pratt
Cryptus No. 1
Ctenichneumon No. 1
Ctenichneumon No. 2
Diadegma insulare (Cress.)
Diadegma No. 1
Dicaelotus No. 1
Dicaelotus No. 2
Dichrogaster No. 1
Diphynus No. 1
Diplazon laetatorius (F.)
Dolichomitus No. 1
Dusoma No. 1
Enicospilus No. 1
Eudelebroea No. 1
Eutanyacra No. 1
Eutanyacra No. 2
Exetastes No. 1
Exochus No. 1
Gelis No. 1
Gelis No. 2
Gelis No. 3
Gelis No. 4
Gelis No. 5
Glypta No. 1
Homotropus No. 1
Hyposoter No. 1
Hyposoter No. 2
Mesochorus agilis Cress.
Netelia No. 1
Netelia No. 2
Phygadreum No. 1

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HYMENOPTERA (CONT'D)

Ichneumonidae (Cont'd)

Pristomerus No. 1
Pterocormus No. 1
Sinophorus No. 1
Triecees No. 1
Venturia No. 1
Vulgichneumon No. 1
Vulgichneumon No. 2
 Ichneumonidae No. 1
 Ichneumonidae No. 2

Mymaridae (7)

Mymaridae No. 1
Mymaridae No. 2
Mymaridae No. 3
Mymaridae No. 4
Mymaridae No. 5
Mymaridae No. 6
Mymaridae No. 7

Trichogrammatidae (3)

Trichogrammatidae No. 1
 Trichogrammatidae No. 2
 Trichogrammatidae No. 3

Eulophidae (65)

Achrysocharis No. 1
Cirrospilus No. 1
Cirrospilus No. 2
Cirrospilus No. 3
Cirrospilus No. 4
Closterocerus No. 1
Diglyphus notauli Gordon
Diglyphus No. 1
Diglyphus No. 2
Euderus No. 1
Euderus No. 2
Euderus No. 3
Euderus No. 4
Horismenus No. 1
Hyssopus No. 1
Hysopus No. 2
Melittobia No. 1
Necremnus No. 1
Necremnus No. 2
Necremnus No. 3
Necremnus No. 4
Necremnus No. 5
Pnigalio No. 1
Pnigalio No. 2
Pnigalio No. 3 and 4
Syntomosolylon No. 1

Tetrastichus No. 1
Tetrastichus No. 2
Tetrastichus No. 3
Tetrastichus No. 4
Tetrastichus No. 5
Tetrastichus No. 6
Tetrastichus No. 7
Tetrastichus No. 8
Tetrastichus No. 9
Tetrastichus No. 10
Tetrastichus No. 11
Tetrastichus No. 12
Tetrastichus No. 13
Tetrastichus No. 14
Tetrastichus No. 15
Tetrastichus No. 16
Tetrastichus No. 17
Tetrastichus No. 18
Tetrastichus No. 19

Eulophidae No. 1
 Eulophidae No. 2
 Eulophidae No. 3
 Eulophidae No. 4
 Eulophidae No. 5
 Eulophidae No. 6
 Eulophidae No. 7
 Eulophidae No. 8
 Eulophidae No. 9
 Eulophidae No. 10
 Eulophidae No. 11
 Eulophidae No. 12
 Eulophidae No. 13
 Eulophidae No. 14
 Eulophidae No. 15
 Eulophidae No. 16
 Eulophidae No. 17
 Eulophidae No. 18
 Eulophidae No. 19

Elasmidae (1)

Elasmidae No. 1

Thysanidae (1)

Thysanidae No. 1

Eutrichosomatidae (1)

Eutrichosomma mirabile Ashmead

Encyrtidae (25)

+ 25 spp. still on loan

Eupelmidae (5)

+ 5 spp. still on loan

Eucharitidae (1)

Eucharitidae No. 1

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HYMENOPTERA (CONT'D)

Perilampidae (3)

- Perilampus* No. 1
Perilampus No. 2
Perilampus No. 3

Torymidae (17)

- Diomorus zabriskiei* Cresson
Microdontomerus anthonomae Crawford
Monodontomerus montivagus
Monodontomerus obscurus
Pseudotorymus No. 1
Torymus aea (Walker)
Torymus aenoscopus (Huber)
Torymus capilaceus albiarsis (Huber)
Torymus citripes (Huber)
Torymus dasyneurae (Huber)
Torymus denticulatus (Breland)
Torymus kinseyi (Huber)
Torymus koebelei (Huber)
Torymus longistigmus (?) (Huber)
Torymus occidentalis (Huber)
Torymus occidentalis No. 1

Torymus

Torymidae No. 1

Torymidae No. 2

Pteromalidae (71)

- Asaphes* No. 1
Callitula No. 1
Catolaccus No. 1
Chlorocythus No. 1
Chlorocythus No. 2
Chlorocythus No. 3
Chlorocythus No. 4
Chlorocythus No. 5
Coelopisthia No. 1
Cyclogastrella No. 1
Cyclogastrella No. 2
Cyclogastrella No. 3
Cyclogastrella No. 4
Cyclogastrella No. 5
Cyclogastrella No. 6
Cyclogastrella No. 7
Cyclogastrella No. 8
Dibrachys No. 1
Eurypteromalus No. 1
Eurypteromalus No. 2
Eurypteromalus No. 3
Gastancistrus No. 1
Gastancistrus No. 2
Gastancistrus No. 3

Gastancistrus No. 4*Habrocytus* No. 1*Habrocytus* No. 2*Habrocytus* No. 3*Habrocytus* No. 4*Habrocytus* No. 5*Habrocytus* No. 6*Habrocytus* No. 7*Habrocytus* No. 8*Halticoptera* No. 1*Halticoptera* No. 2*Halticoptera* No. 3*Halticoptera* No. 4*Halticoptera* No. 5*Halticoptera* No. 6*Heterolaccus* No. 1*Hobbya* (?) No. 1*Hobbya* (?) No. 2*Homoporus* No. 1*Mesopolobus* No. 1*Mesopolobus* No. 2*Mesopolobus* No. 3*Mesopolobus* No. 4*Mesopolobus* No. 5*Mesopolobus* No. 6*Mesopolobus* No. 7*Mesopolobus* No. 8*Pachyneuron* No. 1*Pachyneuron* No. 2*Protolaccus* No. 1*Protolaccus* No. 2*Protolaccus* No. 3*Pseudocatolaccus* No. 1*Pseudocatolaccus* No. 2*Pseudocatolaccus* No. 3*Pseudocatolaccus* No. 4*Pseudocatolaccus* No. 5*Pseudocatolaccus* No. 6*Psilocera* No. 1*Psilocera* No. 2*Pteromalus* No. 1*Rhizomalus* No. 1*Rhizomalus* No. 2*Stinopus* No. 1*Synotomopus* No. 1

Pteromalidae No. 1

Pteromalidae No. 2

Eurytomidae (16)

Bruchopnaqus No. 1*Bruchophagus* No. 2

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HYMENOPTERA (CONT'D)

Eurytomidae (Cont'd)

Eudecatoma No. 1

Eurytoma No. 1

Eurytoma No. 2

Eurytoma No. 3

Eurytoma No. 4

Eurytoma No. 5

Harmolita No. 1

Harmolita No. 2

Megastigma No. 1

Megastigma No. 2

Megastigma No. 3

Rileya No. 1

Eurytomidae No. 1

Eurytomidae No. 2

Chalcididae (8)

Brachymeria tegularis (Cresson)

Chryselampus No. 1

Haltichelini No. 1

Hockeria ruera (Gelt.)

Hypothoracini No. 1

Schwarziella No. 1

Spilochalcis sidae (?)

Chalcididae No. 1

Leucospidae (1)

Leucospis affinis Say

Figitidae (4)

Anacharis No. 1

Aspicera No. 1

Figites No. 1

Neralcia No. 1

Cynipidae (10)

Allotria No. 1

Aporeucoela No. 1

Aporeucoela No. 2

Cothonaspis No. 1

Episoda No. 1

Eucoila No. 1

Hexacola No. 1

Hypodiranchus No. 1

Hypodiranchus No. 2

Kleidotoma No. 1

Gasteruptinidae (1)

Gasteruption No. 1

Proctotrupidae (1)

Proctotrupes No. 1

Ceranophronidae (5)

Aphanogmus No. 1

Ceraphron No. 1

Ceraphron No. 2

Dendrocerus No. 1

Gonostigmus No. 1

Diapriidae (2)

Diapria No. 1

Trichopria No. 1

Scelionidae (15)

Dissolcus No. 1

Gyron myrmecophilus (Ashm.)

Gyron pennsylvanicus (Ashm.)

Gyron No. 1

Holoteleia No. 1

Sporasion No. 1

Telenomus No. 1

Telenomus No. 2

Telenomus No. 3

Telenomus No. 4

Telenomus No. 5

Telenomus No. 6

Trimorus No. 1

Trimorus No. 2

Trissolcus utahensis (Ashm.)

Platygasteridae (8)

Inostemma No. 1

Platygaster No. 1

Platygaster utahensis (Ashm.)

Platygaster No. 1

Platygaster No. 2

Synopeas No. 1

Synopeas No. 2

Synopeas No. 3

Chrysididae (22)

Ceratochrysis perpulchra Cresson

Ceratochrysis crossata (?) R. Bohart

Chrysis australia R. Bohart

Chrysis canadensis Buysson

Chrysis coerulans F.

Chrysis derivata Buysson

Chrysis dorsalis Aaron

Chrysis florissantensis (?) Rohwer

Chrysis No. 1

Chrysis No. 2

Chrysis No. 3

Elampus marginatus Patton

Hedychridium dimidiatum Say

Hedychridium No. 1

Hedychridium No. 2

Holopyga ventralis Say

Omalus plicatus Aaron

Omalus variatus Aaron

HYMENOPTERA (CONT'D)

Chrysididae (Cont'd)

Omalus No. 1*Omalus* No. 2*Omalus* No. 3*Pimpla westcottii*

Bethyridae (6)

Epyris clarimontis Kieffer*Epyris rufipes* Say*Epyris sculleni* Evans*Parasierola* No. 1*Parasierola* No. 2*Pseudisobrachium foutsii* Evans

Dryinidae (2)

Dryinidae No. 1

Dryinidae No. 2

Tiphidae (7)

Brachycistis No. 1*Brachycistis* No. 2*Brachycistis* No. 3*Methocha* No. 1*Myzinum* No. 1*Paratiphia* No. 1*Paratiphia* No. 2

Mutillidae (29)

Acrophotopsis No. 1*Acrophotopsis* No. 2*Chyphotes* No. 1*Chyphotes* No. 2*Emyrmutilla venusta* (Cresson)*Dasytmilla vestita* (Lepelletier)*Dilophotopsis* No. 1*Ephuta* No. 1*Odontophotopsis* No. 1*Odontophotopsis* No. 2*Odontophotopsis* No. 3*Odontophotopsis* No. 4*Odontophotopsis* No. 5*Odontophotopsis* No. 6*Odontophotopsis* No. 7*Pseudomethoca propinqua* (Cresson)*Pseudomethoca* No. 1*Pseudomethoca* No. 2*Sphaerophthalma unicolor* (Cresson)*Sphaerophthalma* No. 1*Sphaerophthalma* No. 2*Sphaerophthalma* No. 3*Sphaerophthalma* No. 4*Sphaerophthalma* No. 5*Sphaerophthalma* No. 6*Sphaerophthalma* No. 7*Sphaerophthalma* No. 8*Timulla grotei* Blake*Typhoctes* No. 1

Scoliidae (1)

Campsoscolia alcione Banks

Sapygidae (1)

Sapyga pumila Cresson

Formicidae (18)

Camponotus laevigatus (Smith)*Camponotus torrefactus* Wheeler*Camponotus vicinus* Mayr*Crematogaster coarctata mormonum*

Emery

Dorymyrmex pyramicus (Roger)*Formica lasioides* Emery*Formica* No. 1*Formica* No. 2*Formica* No. 3*Lasius flavus**Lasius neoniger**Monomorium minimum* Buckley*Myrmicocystus* No. 1*Pheidole* No. 1*Pogonomyrmex occidentalis* (Cresson)*Solenopsis molesta**Stenama occidentalis**Tapinoma sessile* (Say)

Vespididae (4)

Mischocyttarus flavitarsis centralis

Beq.

Polistes fuscatus centralis Hayward*Vespula* No. 1*Vespula* No. 2

Eumenidae (21)

Ancistrocerus adiabatus (Saussure)*Ancistrocerus catskill* (Saussure)*Ancistrocerus tuberculocephalus*

(Saussure)

Eumenes bollii Cresson*Euodynerus annulatus* (Say)*Euodynerus* nr. *annulatus**Euodynerus auranus* (Cameron)*Euodynerus discogaster* Bcquaert*Euodynerus exoglyphus albobittatus*

R. Bohart

Euodynerus foraminatus blandinus

(Roh.)

Leptocheilus rufinodus Cresson*Parancistrocerus acarigaster* R. Bohart

HYMENOPTERA (CONT'D)

Eumenidae (Cont'd)

Parancistrocerus minimoferus R. Bohart
Parancistrocerus pennsylvanicus (Saus.)
Stenodynerus anormis (Say)
Stenodynerus apache R. Bohart
Stenodynerus blandoides R. Bohart
Stenodynerus noticeps R. Bohart
Stenodynerus valliceps R. Bohart
Stenodynerus No. 1
Symmorphus cristatus Saussure

Pompilidae (31)

Ageniella accepta (Cresson)
Ageniella blaisdelli (Fox)
Ageniella conflicti (Banks)
Ageniella euphorbiae Viereck
Ageniella partita Banks
Ageniella No. 1
Agenioideus biedermani (Banks)
Agenioideus birkmanni (Banks)
Anoplius americanus ambiguus (Dlb.)
Anoplius clystera (Banks)
Anoplius nr. illioensis
Anoplius inbellis Banks
Anoplius insolens (Banks)
Anoplius tenebrosus (Cresson)
Aporinellus completus Banks
Aporinellus fasciatus (Smith)
Aporinellus medianus Banks
Aporinellus yucatanensis (Cameron)
Auplopus architectus (Say)
Ceropales rugata Townes
Cryptocheilus hesperus (Banks)
Episyron quinquenotatus (Say)
Episyron snawi (Viereck)
Evagetes hyacinthus (Cresson)
Evagetes pacirinus (Viereck)
Pepsis No. 1
Priocnemis notha navajo Banks
Pompilus orophilus Evans
Pompilus scelestus Cresson

Sphecidae (110)

Alysson melleus Say
Amnoplanellus No. 1
Amnoplanops Cockerelli
Ammophila aberti Haldeman
Ammophila azteca Cameron
Ammophila breviceps F. Smith
Ammophila cleopatra Menke
Ammophila macra Cresson

Ammophila pruinosa Cresson
Ammophila unita Menke
Ammophila varipes Cresson
Astata bakeri Parker
Astata bechteli Parker
Astata nevadica Cresson
Astata occidentalis Cresson
Belomicrus cladothricis
Belomicrus No. 1
Bembix americana spinolae Lep.
Bembix amoena Handlirsch
Bembix occidentalis W. Fox
Bicyrtes capnoptera (Handlirsch)
Bicyrtes ventralis (Say)
Bothynostethis No. 1
Cerceris californica Cresson
Cerceris conifrons Mickel
Cerceris convergens Vier. & Ck11.
Cerceris echo Mickel
Cerceris minax Mickel
Cerceris rufinoda Cresson
Chlorion aerarium Patton
Crabro pallidus W. Fox
Crossocerus No. 1
Didineis peculiaris W. Fox
Dienoplus No. 1
Diodontus No. 1
Diodontus No. 2
Diploplectron No. 1
Dryudella kohli (Cameron)
Dryudella rhimpa Parker
Ectemnius besseya (Rohwer)
Ectemnius continuus (F.)
Ectemnius sonorensis (Cameron)
Epinysson bellus (Cresson)
Eucerceris canaliculatus (Say)
Eucerceris vittatifrons Cresson
Fernaldina lucae (Saussure)
Corytes canaliculatus Parker
Corytes provancheri Handlirsch
Hoplisoides punctifrons (Cameron)
Hoplisoides splendidulus Bradley
Isodontia elegans Smith
Larropsis vegeta
Lastica producticollis (Packard)
Lindenius columbianus (Kohl)
Lindenius No. 1
Lyroda subita Say
Mellinus rufinodus Cresson
Mimesa No. 1

HYMENOPTERA (CONT'D)

Sphecidae (Cont'd)

Mimesa No. 2
Motes argentata (Palisot-Beauvais)
Nysson gagates Bradley
Ochleroptera bipunctata (Say)
Oxybelus emarginatus Say
Oxybelus fossor R. + C.
Oxybelus packardii Robertson
Oxybelus parvus Cresson
Oxybelus uniglumis (L.)
Palmodes dimidiatus (DeGeer)
Passaloeucus No. 1
Pemphredon inornatus Say
Pisonopsis No. 1
Philanthus gibbosus (F.)
Philanthus multimaculatus Cameron
Philanthus pacificus Cresson
Plenoculus davisii W. Fox
Plenoculus No. 1
Podalonia communis (Cresson)
Podalonia luctuosa F. Smith
Podalonia mexicana (Saussure)
Podalonia sericea Murray
Podalonia valida (Cresson)
Priononyx canadensis Cresson
Pulverro No. 1
Sceliphron caementarium Drury
Solierella No. 1
Solierella No. 2
Sphex ichneumonius (L.)
Spilomena No. 1
Spilomena No. 2
Steniolia duplicata Provancher
Steniolia elegans J. Parker
Stictiella nubilata Gillasp
Stictiella plana W. Fox
Stigmus No. 1
Stizoides uncinatus (Say)
Tachysphex aequalis W. Fox
Tachysphex alpestris Rohwer
Tachysphex ashmeadi Fox
Tachysphex cockerellae Rohwer
Tachysphex propinquus Viereck
Tachysphex tarsatus Say
Tachysphex No. 1
Tachytes distinctus Smith
Tachytes ermineus Banks

Tachytes hesperus Banks
Tachytes nevadensis R. Bohart
Trypoxylon No. 1
Trypoxylon No. 2
Trypoxylon No. 3
Zanysson texanus (Cresson)

Colletidae (9)

Colletes compactus Cresson
Colletes dissoptus Timberlake
Colletes simulans Cresson
Colletes No. 1
Hylaeus affinis F. Smith
Hylaeus calvus Metz
Hylaeus cressoni (Cockerell)
Hylaeus stevensi Crawford
Hylaeus No. 1

Andrenidae (33)

Andrena colletina Cockerell
Andrena cressoni Robertson
Andrena erythrogaster Ashmead
Andrena helianthi Robertson
Andrena mimetica Cockerell
Andrena miserabilis Cresson
Andrena nigrae Robertson
Andrena nimbicula Smith
Andrena placida Smith
Andrena prunorum Cockerell
Andrena ramaleyi Cockerell
Andrena scurra Viereck
Andrena walleyi Cockerell
Andrena No. 1
Andrena No. 2
Andrena No. 3
Calliopsis coloradensis Cresson
Nomadopsis scitula Cresson
Perdita albipennis Cresson
Perdita caloleuca Cockerell
Perdita nuda Cockerell
Perdita rectangularis Cockerell
Perdita salicis Cockerell
Perdita similis Timberlake
Perdita stottleri Cockerell
Perdita tortifoliae Cockerell
Perdita zebrata Cresson
Perdita No. 1
Perdita No. 2
Perdita No. 3
Pseudopanurgus No. 1

HYMENOPTERA (CONT'D)

Andrenidae (Cont'd)

Pseudopanurgus No. 2

Halictidae (31)

Agapostemon femoratus Crawford*Agapostemon texanus* Cresson*Dialictus* No. 1*Dialictus* No. 2*Dialictus* No. 3*Dialictus* No. 4*Dialictus* No. 5*Dialictus* No. 6*Dialictus* No. 7*Dialictus* No. 8*Dialictus* No. 9*Dialictus* No. 10*Dialictus* No. 11*Dialictus* No. 12*Evylaeus ovaliceps* Cockerell*Evylaeus* No. 1*Evylaeus* No. 2*Evylaeus* No. 3*Evylaeus* No. 4*Haliectus confusus* Smith*Haliectus farinosus* Smith*Haliectus ligatus* Say*Haliectus rubicundus* Christ*Haliectus tripartitus* Cockerell*Haliectus virgatus* Cockerell*Lasioglossum mellipes* Crawford*Lasioglossum sisymbrium* Cockerell*Nomia melanderi* Cockerell*Sphecodes* No. 1*Sphecodes* No. 2*Sphecodes* No. 3*Sphecodes* No. 4

Megachilidae (33)

Antidiellum notatum (Latreille)*Anthidium edwardsii* Cresson*Ashmeadiella buceonis* Say*Ashmeadiella cactorum* Cockerell*Ashmeadiella meliloti* Cockerell*Coelioxys* No. 1*Coelioxys* No. 2*Dianthidium curvatum* (Smith)*Dianthidium pudicum* (Cresson)*Dianthidium ulkei* (Cresson)*Heriades variolosa* Cresson*Hoplitis grinnelli* Cockerell*Megachile agustini* Cockerell*Megachile coquilletti* Cockerell*Megachile dentitarsis* Sladen*Megachile gentilis* Cresson*Megachile nevadensis* Cockerell*Megachile onobrychidis* Cockerell*Megachile pacifica* Panzer*Megachile parallela* Smith*Megachile perihirta* Cockerell*Megachile subexilis* Cockerell*Megachile subnigra* Cresson*Megachile texana* Cresson*Megachile wheeleri* Mitchell*Osmia integra* Cresson*Osmia lignaria* Say*Osmia* No. 1*Osmia* No. 2*Osmia* No. 3*Osmia* No. 4*Osmia* No. 5*Osmia* No. 6

Anthophoridae (29)

Anthophora affabilis Cresson*Anthophora albata* Cresson*Anthophora* nr. *crotchii* Cresson*Anthophora edwardsii* Cresson*Anthophora* nr. *edwardsii* Cresson*Anthophora exigua* Cresson*Anthophora maculifrons* Cresson*Anthophora occidentalis* Cresson*Anthophora porterae* Cockerell*Anthophora urbana* Cresson*Anthophora ursina* Cresson*Ceratina nanula* Cockerell*Diadasia enavata* Cresson*Melecta pacifica* Cresson*Melectomorpha californica* (Cresson)*Melissodes agilis* Cresson*Melissodes bimatrix* LaBerge*Melissodes dagosa* Cockerell*Melissodes glenwoodensis* Cockerell*Melissodes subagilis* Cockerell*Melissodes* No. 1*Neolarra* No. 1*Neolarra* No. 1*Nomada articulata* Smith*Nomada fragilis* Cresson*Nomada suavis* Cresson*Tetralonia actiosa* Cresson*Tetralonia frater* Cresson*Tetralonia fulvitaris* Cresson

SPECIES LIST -OIL SHALE TRACTS

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HYMENOPTERA (CONT'D)

Apidae (3)

Apis mellifera L.

Bombus huntii Greene

Bombus morrisoni Cresson

ARACHNIDA

ARANEIDA (22)

Lycosidae (2)

Pardosa No. 1

Trochosa gosiuta (Chamberlin)

Clubionidae (3)

Chiricanthium inclusum (Hentz)

Agroeca trivittata (Keyserling)

Castianeira No. 1

Thomisidae (5)

Xysticus No. 1

Tmarus angulatus (Walckenaer)

Misumenops coloradensis Gertsch

Misumenops No. 1

Misumena vatia (Clerck)

Salticidae (2)

Philodromus alascensis Keyserling

Sassacus papenhoei Peckham and Peckham

Dictynidae (2)

Argenna obesa Emerton

Dictyna terranea Ivie

Oxyopidae (1)

Oxyopes No. 1

Tetragnathidae (1)

Tetragnatha versicolor (Walckenaer)

Amaurobocidae (1)

Titanocعا No. 1

Gnaphosidae (3)

Zelotes No. 1

Gnaphosa No. 1

Poecilochroa No. 1

Theridiidae (1)

Latrodetes No. 1

Steatoda americana Emerson

Pholcidae (1)

Psilochorus imitatus Gertsch and Mulaik

CHARACTERIZATIONS OF TERRESTRIAL INVERTEBRATE FAMILIES

Order PSOCOPTERA (lice) 1 family.

Psocidae (bark lice) 1 species. Small, delicate insects with wide heads, large wings, soft bodies that shrivel when dry. Nymphs and adults usually found on bark feeding on spores, lichens, insect fragments.

Order THYSANOPTERA (Thrips) 5 families. Usually minute, elongate insects with feathery fore and hind wings, with rasping mouthparts.

Aelolothripidae (broad-winged thrips) 2 species. Wings relatively broad, rounded apically, usually banded. Predaceous on other minute insects.

Thripidae (common thrips) 4 species. Large family of small thrips with narrow wings, 6-9 antennal segments. Both stages mostly plant feeders, rasping and sucking juice from petals, buds, young leaves, pollen, young fruit, bulbs, etc.

Phloeothripidae (phloeothripids) 4 species. Usually dark colored (often metallic) thrips with tubular ovipositor and very narrow wings. Most species predaceous on mites and other thrips in both stages.

Merothripidae (large-legged thrips) 1 species. Front, hind femora enlarged, pronotum with two longitudinal sutures. Probably predaceous.

Heterothripidae (heterothripids) 1 species. Flattened thrips with 9-10 segmented antennae. Adults and nymphs reported to be phytophagous.

Order HEMIPTERA (Bugs) 29 families. Insects with incomplete metamorphosis and long sucking beak.

Suborder HETEROPTERA (true bugs) 17 families. Forewings usually half coriaceous, half membranous.

Anthocoridae (minute pirate bugs) 3 species. Small black and white or brown and white oval bugs. Commoner species usually on flowers in both stages but others (larger species) found under loose bark, in litter. Largely predaceous on insects, insect eggs and mites but some species occasionally sucking sap from petals, etc.

Miridae (leaf bugs or plant bugs) 42 species. Usually small, rather delicate bugs with downward bent wing tips in

repose. A large family with many abundant species. Species almost entirely feeding on plant sap but a few occasionally predaceous.

Phymatidae (ambush bugs) 1 species. Stout-bodied bugs with short raptorial front legs. Usually lie in wait on flowers of their own color to pounce on bees, wasps, flower-visiting flies. Common on yellow composites at Bonanza.

Reduviidae (assassin bugs) 3 species. Medium to large-sized bugs with narrow head (neck-like behind) and short, curved proboscis. Most species predaceous on other insects. A few (not seen at Bonanza) blood suckers on mammals.

Ploiariidae (thread-legged bugs) 1 species. Very slender, with raptorial front legs, stilt-like mid, hind legs. Found in litter, at base of grass tufts (which they resemble) where they prey on other insects. Rare at Bonanza.

Nabidae (damselfly bugs) 1 species. Rather slender bugs, narrowed anteriorly, with weakly raptorial front legs. Predaceous on mirid nymphs aphids, small caterpillars, etc. Very abundant at Bonanza.

Tingidae (lace bugs) 2 species. Small, flat bugs with sculptured, lace-like armature on upper surface. Adults nymphs feed on leaf surfaces, causing early drop.

Piesmididae (ash-gray leaf bugs) 2 species. Similar to lace bugs but more slender, less lacy. Feed on foliage of shrubs. Bonanza species taken on *Lepidium*.

Neididae (stilt bugs) 1 species. Like ploiariids but with all legs stilt-like. Feed on plant sap in dense herbaceous vegetation. Swept from wet meadow by White River.

Lygaeidae (seed bugs) 10 species. Large family, mostly sap suckers, but some (*Geocoris*, *Myodocha*) more often predaceous. Many suck sap from developing seeds. At Bonanza, false chinch bugs (*Nysius*) extremely common on many plants.

Coreidae (leaf-footed bugs) 1 species. Medium to large-sized elongate-oval, strong scented bugs. Often with expanded hind legs. Most are phytophagous but a few predaceous. Largest species at Bonanza feeds on cactus. Most abundant species common on *Chrysothamnus*, other plants.

Rhopalidae (scentless plant bugs) 4 species. Like *Coreidae* but lack scent glands and usually smaller and lighter colored. Phytophagous, principally on shrubs and grasses. All species recorded for Bonanza abundant except for *Niesthria sidae*.

Coriscidae (broad-headed bugs) 1 species (also known as *Alydidae*) Strong scented, narrow, parallel-sided bugs related to *Coreidae*. Resemble spider-wasps when in action. Suck sap from shrubs.

Aradidae (flat bugs) 1 species. Very flat, oval, dark-colored bugs found mostly under bark. Adults, nymphs suck sap from fungi. Bonanza species found under dead cottonwood bark.

Corixidae (water boatmen) 1 species. Aquatic insects, swimming back uppermost with oar-like movement of hind legs. Non-biting. Feed on algae, minute aquatic organisms, a few on midge larvae.

Saldidae (shore bugs) 2 species. Small, oval, flattened bugs that run or take quick short flights along shore-lines. Sometimes burrowing. Predaceous on other insects. Very common along shores of White River.

Corimelaenidae (negro bugs) 1 species. Small, nearly round, convex shining bugs. Scutellum covers most of abdomen. Phytophagous on low vegetation.

Pentatomidae (stink bugs) 7 species. Medium to large-sized bugs with broad shield-shaped, large triangular scutellum. Strong scented. Most species phytophagous, some both predaceous and phytophagous (rough shield bugs).

Suborder HOMOPTERA (Whole-winged bugs) 12 families. Forewings uniform.

Cicadidae (cicadas) 1 species. Large, usually transparent-winged, non-jumping insects with loud sound-producing abdominal tymbals. Eggs laid in twigs, nymphs feed underground on roots (4 to 17 years), adults on twigs but damage plants chiefly by egg laying. Bonanza species commonest on *Artemisia*.

Membracidae (tree hoppers) 4 species. Hoppers with large prosotum concealing head and abdomen, usually hump-backed in appearance. Most species feed on trees and shrubs, frequently taking sap from stem tissue; a few in nymphal stage feeding on herbaceous plants. Most abundant species in Bonanza taken from composite shrubs.

Cercopidae (froghoppers, spittlebugs) 3 species. Like leafhoppers but without double row of spines of hind tibia. Feed on sap of shrubs and herbaceous plants, usually rather specific. Nymphs cover themselves with mass of bubbles. Most abundant species at Bonanza not host specific. With posterior eye-spots to confuse predators.

Cicadellidae (leafhoppers or sharpshooters) 75 species. Large family of streamlined insects with hind tibia provided with double row of spines. All species suck plant juice, usually from leaves; most species somewhat host specific. Many species transmit plant viruses.

Cixiidae (transparent planthoppers) 5 species. Nymphs feed on roots of plants, especially grasses; adults on above-ground parts. At Bonanza commonest in the spring on rice grass in upland areas and wet meadow by pumphouse overflow near White River.

Delphacidae (flat spurred planthoppers) 7 species. Small, usually transparent-winged insects with flat hind tibial spurs, many with reduced wings. Favor herbaceous plants, nymphs often feeding at crowns, wet meadow at White River crossing a favorite spot at Bonanza.

Dietyopharidae (horned planthoppers) 3 species. Usually with head prolonged anteriorly. Both stages feed primarily on grasses.

Issidae (robust plant hoppers) 2 species. Compact plant hoppers, sometimes with short wings. Principal species at Bonanza taken sweeping *Artemisia*.

Psyllidae (jumping plant lice) 12 species. Small hoppers resembling minute cicades. Suck above-ground plant juices (usually shrubs, trees, generally host specific.) At Bonanza, one species extremely common on *Rhus*, 2 others on *Artemisia*.

Aleyrodidae (whiteflies) 1 species. Minute insects, with wings covered with white powder. Nymphs scale-like, usually found on undersides of leaves.

Aphididae (plant lice, aphids) 18 species. Large family of soft-bodied delicate often wingless homopterans with pair of horn-like cornicles on abdomen which secrete wax. Most species secrete honeydew. Some species tended by ants. Many species at least in part, parthenogenetic. At Bonanza, especially abundant in species on *Chrysothamnus*, *artemisia*.

Order TRICHOPTERA (Caddisflies) 4 families. Adults moth-like but with hairy (not scaly) wings. Larvae aquatic, make cases in which to live.

Hydropsychidae (net-spinning caddisflies) 2 species. Adults with elongate terminal maxillary palpal segment. Aquatic larvae spin net in front of cylindrical case. Common along White River.

Hydroptilidae (micro-caddisflies) 2 species. Minute caddisflies with mottled wings. Larvae usually in ponds or lakes. Adults at Bonanza taken in light trap.

Leptoceridae (long-horned caddisflies) 1 species. Slender, usually pale caddisflies with antennae much longer than body. Larvae usually in stream, make variety of ease types. Common along White River.

Lepidostomatidae (lepidostomatid caddisflies) 1 species. Small family of small caddisflies. Larvae stream inhabiting. One specimen at Bonanza taken at light.

Order LEPIDOPTERA [butterflies (diurnal) & moths (usually nocturnal)] 28 families. Insects with scale-covered bodies and wings and with tongues. Larvae phytophagous, adults generally nectarivorous.

Pieridae (whites, sulphurs) 5 species. Medium-sized to small butterflies, usually white or yellow with marginal black markings and normal front legs. The naked green larvae of most species feed on cruciferous plants. *Lepidium* apparently the principal host plant at Bonanza.

Papilionidae (swallowtails and parnassians) 1 species. Large butterflies, most with tail-like prolongation of hind wing. Larvae of most species feed on leaves of large shrubs or trees but some on herbs such as umbellifers and *Aristolochia*. Bonanza species, *Papilio bairdi* Edw., a rare species found in isolated populations in the Intermountain region, conceivably a candidate for endangered species list. Its larvae feed on umbellifers.

Satyridae (satyrs, wood nymphs, meadow nymphs) 2 species. Small to medium-sized butterflies, grey or brown with small eye-like spots on the wings. Larvae feed on grasses. Adults found in grassy areas.

Danaidae (milkweed butterflies) 1 species. Large, usually brown species with unclawed but non-brush-like front legs. Larvae feed on milkweed, distasteful to birds. The monarch (as represented in Bonanza) winters in California.

Nymphalidae (brush-footed butterflies) 7 species. Large, diverse family with brush-like front tarsi. Two Bonanza species (viceroy and mourning cloak) have larvae that feed on willow.

Riodinidae (metal marks) 1 species. Small darting butterflies with many small white marks, especially on underside of wings. At Bonanza, found on *Chrysothamnus* in upland areas.

Lycaenidae (blues, coppers, hairstreaks) 3 species. Small, delicate butterflies, usually brightly colored. Larvae feed on many plants but especially legumes, a few (because of sweet secretions) tended by ants or live in ant nests. One genus predaceous on aphids (predatory habit very rare in Lepidoptera).

Hesperiidae (skippers) 3 species. Small, stout-bodied butterflies with hood on antennal club, with large-headed, small-necked larvae. Two of Bonanza species most common on *Chrysothamnus*.

Arctiidae (tiger and leopard moths) 2 species. Medium-sized, robust moths with light ground color, strongly contrasting patterns. Larvae (called wooly bears) usually with long, dense pubescence. Larvae feed on wide variety of herbs, woody plants.

Sphingidae (hawk noths, hornworms) 1 species. Medium sized to large stout-bodied, narrow-winged noths with thick antennae enlarged subapically. Bonanza species *Celerio lineata* cosmopolitan, its larvae feeding on *Oenothera* (which the adults pollinate) and certain other plants.

Noctuidae (noctuid moths, nun moths) 53 species. The largest lepidopteran family. Medium-sized moths, usually stout-bodied with forewings considerably narrower than hind. Larvae (generally called cutworms) usually almost naked, usually pupate naked in the soil (often overwinter in soil as nearly grown larvae). Many species present at Bonanza, conspicuous at lights on certain nights. The largest (*Catocala* sp) cryptically marked when at rest on cottonwood bark. Its larvae feed on cottonwood leaves.

Notodontidae (prominents) 1 species. Resemble noctuids as adults; larvae with conspicuous dorsal tubercles. Larvae usually feed on trees or shrubs.

Lasiolepididae (lappet moths, tent caterpillars) 1 species. Adults resemble noctuids but hairier, with more feathery antennae. Larvae moderately hairy or bristly and highly gregarious, forming a tight web or tent on trees or large shrubs. At Bonanza, one such tent seen on *Amelanchier*.

Olethreutidae (coddling moth, oriental fruit moth, etc.) 3 species. Small moths resembling tortricids but larvae usually attacking fruit or nuts. Some roll leaves but don't tie them together. One species at Bonanza destructive to berries of *Rhus*.

Pyrallidae (snout moths) 8 species. A large family of small to medium-sized moths, usually dull colored with

triangular outline at rest, with palpi forming "snout" in front of head. Larvae feed on living leaves, or bore in stems, or fold leaves, or feed in stored plant products or feed on crowns, roots of grasses, etc.

Pyromorphidae (smoky moths) 1 species. Small dark-colored moths, often with bright-colored hind wings. Larvae are lead skeletonizers.

Ctenuchidae (wasp moths) 1 species. Day flying moths, somewhat wasp-like with dark often metallic wing patterns. Larvae feed on grasses, lichens.

Geometridae (geometers, inch worms, measuring worms) 13 species. Adults slender bodied, with broad, delicate wings sometimes with angulate margins. Larvae slender, nearly naked, mimicking twigs when alarmed. Progress in "inch-worm" fashion. Most feed on trees or shrub but a few on herbs.

Alucitidae (many-plume moths) 1 species. This family (only one North American species) has each wing split into six divisions. Its larval habits are unknown although it is abundant at Bonanza, often being trapped in automobiles on the windshield.

Sessiidae (clear-winged moths) 1 species. Wasp-like moths with narrow clear wings. Larvae bore in roots, stems, canes, trunks of plants. Adults diurnal.

Saturniidae (giant silkworm moths) 1 species. Large, broad-winged moths, usually with eye spots on wings, males with broadly feathered antennae. Larvae feed on shrubs, trees. Our species (*Pseudohazis* sp.) diurnal in flight with larvae feeding on *Artemisia*, *Ceanothus* in upland areas.

Gelechiidae (gelechiid moths) ? species. A large family of very small moths with hind wings usually curved distally. Larvae usually leaf miners, leaf rollers, leaf tyers or stem gall formers. One species is serious grain pest, another bores in tubers. Almost nothing is known of the many species at Bonanza (mostly taken in Malaise traps).

Plutellidae (diamondback moths) ? species. Very small moths that hold antenna straight forward when at rest. Larvae eat small holes in leaves, attach silken cocoons to leaf surface. Usually attack herbaceous plants. One species at Bonanza (diamondback moth) a serious pest of crucifers.

Coleophoridae (casebearers) ? species. Very small moths with narrow, sharply pointed wings and no ocelli or maxillary palpi. Larvae mine leaves when young, bear cases when older.

Gracilariidae (leaf-blotch miners) ? species. Very small to minute moths when at rest, with anterior part of body elevated and wing tips touching substrate. Most larvae leaf miners, one at Bonanza commonly mining cottonwood leaves.

Tineidae (clothes moths, etc.) Very small moths with large, folded maxillary palpi, reduced labial palpi. Larvae case-bearers, scavengers, fungus feeders, or feed in hair, the last named group eating wool and silk.

Scythridae (scythrid moths) 1 species. Small family of small moths with wings only slightly fringed. Larvae fold leaves while feeding on them.

Phaloniidae (web worms) 1 species. Resemble tortricids but with reduced venation. Larvae spin webs between coniferous needles or bore in stems and make silken sheath. Bonanza species lives in silk tubes that fasten juniper needles together.

Order NEUROPTERA (lacewings) 6 families.

Raphidiidae (snakeflies) 1 species. Prothorax several times as long as broad, forelegs not raptorial. Larvae predaceous under bark. Adults prey on weak or small insects. At Bonanza, common on *Juniperus* in upland areas.

Coniopterygidae (dustywings) 3 species. Small insects, covered with whitish powder. Commonest species at Bonanza swept from *Atriplex* in upland area. Also taken at lights. Larvae feed on minute insects, mites, eggs.

Hemerobiidae (brown lacewings) 4 species. Smaller than common lacewings, dark brown. Frequently at lights. Adults and larvae predaceous. Common along White River.

Berothidae (beaded lacewings) 1 species. Like hemerobiids, but wings indented apically, covered with more hairs, scales. Eggs stalked (as in chrysopids). Larvae predaceous.

Chrysopidae (common lacewings, golden eyes) 3 species. Medium-sized with copper eyes, usually green wings, often odoriferous. Eggs laid on stalks, larvae feed in open primarily on aphids. Frequently taken at lights, Common throughout Bonanza area.

Myrmeleontidae (antlions) 2 species. Large with long wings, abdomens (especially males) antennae clubbed. Larvae usually form conical ant-traps in sand or dust but some merely burrow in sand. Frequently at lights. At Bonanza, most common in upland areas especially around base of cliffs.

Order COLEOPTERA (beetles) 47 families. Insects with complete metamorphosis, chewing mouthparts, usually hard wing-covers (forewings) covering and protecting hind wings and abdomen.

Suborder ADEPHAGA

Carabidae (predaceous ground beetles) 24 species. Usually black, flattened beetles with spiny legs and several mandibular teeth. Large family of predaceous beetles, mostly found under rocks, logs, etc. Larvae mostly in soil. Some adults fly to lights, taken in pit-traps during nocturnal foraging. Most species at Bonanza taken along White River.

Gyrinidae (whirligig beetles) 1 species. Like dytiscids but with flange around margin and with eyes divided into below water and above water sets. Adults skate in groups on water surface where they are scavengers. Larvae are submerged and predaceous. Bonanza species collected in pond near White River.

Dytiscidae (predaceous diving beetles) 4 species. Flattened, oval beetles with oar-like hind legs. Aquatic and predaceous as larvae and adults. Larvae breathe with gills, adults by trapping air under wing covers. Adults fly to lights.

Cicindellidae (tiger beetles) 3 species. Long-legged, somewhat flattened, oblong beetles, usually metallic, especially under wing covers. Fast-flying predaceous beetles found on damp sand or mud or along roads or trails. Larvae inhabit vertical burrows which they operate as traps. One species common on sandy banks of White River and Evacuation Creek.

Suborder POLYPHAGA 40 families.

Histeridae (hister beetles) 2 species. Compact, shiny, hard-shelled beetles with one or two abdominal segments exposed. Adults and larvae predaceous on insects found in dung, carrion, oozing sap, under bark, in beetle galleries, in ant and termite nests. Also commonly found as predators of insects in mammal and bird nests.

Hydrophilidae (water scavenger beetles) 7 species. Resemble dytiscids but less flattened, with less modified hind legs. Most species aquatic in both stages and adults flying to lights. Adults usually scavengers but larvae predaceous. One subfamily terrectrial in dung where both stages feed on dipterous larvae.

Limnebiidae (minute moss beetles) 1 species. Minute oval, black beetles resembling hydrophilids but six or more

abdominal stema instead of five. Adults, larvae scavengers in matted vegetation along shorelines, sometimes found swimming near food areas. Bonanza species taken at light.

Ptiliidae (feather-winged beetles) 1 species. Smallest of all beetles with hind wings feather-like. Feed on fungus spores, usually in rotten wood. Species at Bonanza taken by White River from large wood fungus on cottonwood log.

Silphidae (carrion beetles, sexton beetles). 2 species. Large, flattened, soft-wing covered beetles, usually found feeding on carrion in larval and adult forms. One genus at Bonanza (*Nicrophorus*) buries dead animals.

Staphylinidae (rove beetles) 28 species. Large family of slender beetles with several exposed abdominal segments. Occur in varied habitats, but especially carrion, dung, under stones, in fungi, decaying vegetation, etc. Most species both predaceous and scavenging but some parasitic or inquili-nous in ant, termite nests. Commonly taken at lights.

Pselaphidae (short-winged mold beetles) 1 species. Very small beetles with clubbed antennae, short, squared-off wing covers. Most are found in moldy litter where they probably feed on mites. Some species live as ant guests.

Cantharidae (soldier beetles, leather-winged beetles) 3 species. Slender, flattened beetles with leathery wings. Adults of most species feed on pollen but some feed on herbage. Most species of larvae predaceous but a few are omniverous. At Bonanza one species extremely common on *Chrysothamnus* along White River.

Lampyridae (fire flies) 1 species. Flattened, leathery beetles with head hidden under prothorax. Adults of many species flash abdominal luminescence. Non-luminescent adults may have 1 uminescent larvae (as Bonanza species). Larvae predaceous on many soil invertebrates, adults non-feeding.

Dermestidae (skin beetles, carpet beetles) 5 species. Compact, oval, brittle beetles with hairy larvae. Both forms feed on dry animal and plant materials of high protein content such as pollen stores, dried insects, hair, dessicated car-casses, grain stores, etc.

Melyridae (soft-winged flower beetles) 9 species. Small beetles of two types, one flattened with short, squared-off, soft wing covers, the other with full length rounded slytra of grey or grey and black spotted color. Adults feed on pollen, some also predaceous. Larvae predaceous on small insects. At Bonanza, adults often very abundant on wide variety of blossoms, especially in upland area.

Dasytidae (dasytid beetles) 9 species. Related to melyrids but with harder wing covers, usually more convex. Small to minute beetles, often very abundant on desert shrubs. Adults and larvae predaceous on small, soft-bodied arthropods.

Trogositidae (bark-gnawing beetles) 1 species. Subfamily of Bonanza species (*Tenebroidinae*) parallel-sided, with pronotum separated widely from base of wing covers. Jaws massive. Adults & larvae of known species found in stored grain where they are predaceous and granivorous.

Dleridae (checkered beetles) 5 species. Usually active, brightly marked beetles with large heads and with hairy pink larvae. Usually predaceous in both stages on other insects. The commonest western species feeds on pollen as adult, lives in nests of bees and wasps as larva.

Elateridae (click beetles, true wire worms) 3 species. Elongate, hard beetles that flip into the air when lying on their backs. Larvae (wire worms) mostly vegetarian on roots but a few are predaceous. Adults feed on foliage, under bark.

Buprestidae (metallic wood-boring beetles, flat-headed borers) 4 species. Hard, stream-lined, elongat-oval beetles usually metallic colored or with contrasting patterns. Larvae bore in logs and roots or mine stems of herbaceous and woody plants. Some adults feed on foliage, others on fungus, others on pollen. All three adult habits represented in the 4 species at Bonanza.

Heteroceridae (variegated mud beetles) 3 species. Flattened, oblong, pubescent beetles with dilated, spiny fore and midtibial. Adults and larvae live in galleries in mud banks of streams. Food habits unknown. Adults fly to lights. Very common along banks of White River.

Cryptophagidae (silken fungus beetles) 2 species. Small, rounded beetles with clubbed antennae. Adults and larvae feed on fungi, decaying leaves, sometimes as scavengers in nest of bees.

Phalacridae (shining flower beetles) 5 species. Small, oval, very convex, shining black beetles. Basic habits unknown but both adults and larvae found in flowers. At Bonanza, sometimes very common on *Chrysothamnus* blossoms.

Nitidulidae (sap beetles) 5 species. Small, flat beetles with truncated wing covers. Adults feed on flowers or decaying fruit, fermenting sap or fungi. Larvae feed in decaying fruit and fungi.

Lathridiidae (minute brown scavenger beetles) 1 species. Minute oval beetles with 3-segmented tarsi. Known to live in moldy material such as moldy stored food. Species at Bonanza taken in light trap.

Coccinellidae (ladybird beetles) 18 species. Small, convex, nearly round beetles, often conspicuously spotted. Adults and larvae predaceous on soft-bodied insects or mites. Larvae (alligator-like) search for prey, feed in open.

Colydiidae (cylindrical bark beetles) 2 species. Hard-bodied, cylindrical, polished beetles, usually found in galleries of other beetles in wood. Larvae predaceous or ectoparasitic on larvae of other beetles. Some presumed to be fungivores.

Cerylonidae (cerylonid beetles) 1 species. Small, oval, flattened beetles with antennal club 2-segmented. Habits unknown.

Mycetophagidae (hairy fungus beetles) 2 species. Flattened, obovate beetles covered with short hair. Adults, larvae feed on fungi and are commonly found in shelf fungi or under bark with fungus-covered cambium. Those at Bonanza collected under bark of old cottonwood logs.

Anthicidae (ant-like flower beetles) 8 species. Small, flat beetles with body divisions very distinct. Adults commonly on flowers, larvae predaceous in vegetable debris or organic material in moist sand.

Oedemeridae (false blister beetles) 3 species. Slender, convex beetles with anteriorly expanded pronotum. Adults very common at Bonanza on flowers and at lights. Larvae feed in woody debris along stream margins. Very common along Evacuation Creek.

Meloidae (blister beetles) 9 species. Usually elongate, convex beetles with soft wing covers and large heads. Adults phytophagous (and often nectar feeding) or non-feeding. Larvae feed on grasshopper egg masses or cuckoo-like in nests of bees. In Bonanza, gumplant (*Grindelia*), *Chrysothamnus* with abundant forms *Anthophora* bee nests in clay banks of Evacuation Creek with highly specialized, wingless, meloid parasite.

Rhipiphoridae (rhipiphorid beetles) 1 species. Wedge-shaped beetles with branched antennae (sometimes with very short wing covers) functioning as specialized parasites of nesting Hymenoptera. Larvae change into various forms (hypermetamorphosis). Adults found on flowers, especially composites.

Mordellidae (tumbling beetles) 6 species. Small, wedge-shaped beetles with pointed abdomens. Adults flower feeders. Larvae poorly known, some predaceous in rotten wood others probably leaf or stem miners. At Bonanza, often very abundant on sweetclover, *Eriogonum*, various other flowers.

Alleculidae (comb-claw beetles) 1 species. These beetles look like delicate tenebrionids. Adults feed on pollen or on fungus spores under bark. Larvae live in rotten logs, in fungi or vegetable debris.

Tenebrionidae (darkling ground beetles) 21 species. A large family of hard-shelled beetles with diverse forms and habits. Feed as scavengers on decaying vegetation, dung, rotten wood, fungi, a few on living roots (as larvae) or on flowers (as adults). Several common species (known as teeterasses) tilt abdomen in air in preparation for aerosol attacks.

Melandryidae (false darkling beetles) 1 species. Elongate-oval, flattened, dark-colored beetles with two dents near posterior border of pronotum. Larvae and adults found in dry wood or under bark of dead deciduous trees. Adults sometimes on flowers. Some larvae carnivorous; others predaceous.

Anobiidae (death watch beetles) 1 species. Beetles with strongly deflexed heads. Larvae live in bark of dead trees or old dry wood (as furniture). Some feed on dry tobacco, spices, etc.

Ptinidae (spider beetles) 1 species. Strongly convex spider-like beetles with food habits similar to those of dermestids. Bonanza species found in *Osmia* bee nests in clay banks by Evacuation Creek.

Scarabaeidae (scarab beetles) 12 species. Large family of robust, phytophagous beetles with antennal segments arranged like book leaves. Larvae usually feed in soil (known as whitegrubs), adults more commonly aboveground in flowers, on leaves, in dung, in decaying fruit. A few (as *Cremastocheilus* in Bonanza) inquilines in ant nests.

Cerambycidae (longhorn beetles) 4 species. Large family of medium to large-sized usually elongate beetles with long antennae. Adults, larvae phytophagous, the larvae boring into wood and roots or small stems; the adults feeding on wood, leaves, pollen, other flower parts. Often quite host specific. Two of species at Bonanza common on milkweed.

Chrysomelidae (leaf beetles) 28 species. Large family with variable form often superficially resembling ladybird

beetles. Apparently all are phytophagous as adults and larvae, usually feeding on leaves but some on stems and roots. Most species are host specific.

Bruchidae (bean weevils) 3 species. Compact little beetles with exposed pygidium, small deflexed head. Larvae develop in seeds, especially leguminous. Adults feed on pollen in flowers. In Bonanza common on *Astragalus*.

Curculionidae (snout beetles, weevils) 25 species. Large family of beetles with long or short snout and geniculate antennae. All species phytophagous in both stages. Larvae of most species live within living host tissue but some feed externally on roots or leaves and others feed on dead plant material or stored seeds, etc. Adults of some species common on flowers. Host specificity usual.

Platypodidae (pin-hole borers) 1 species. Bark beetle-like but more elongate. Larvae bore in sick trees, cultivate fungi in their galleries. Adults of Bonanza species taken in light trap.

Scolytidae (bark beetles) 1 species. Small, cylindrical beetles with geniculate, clubbed antennae. Larvae of most species live in galleries in cambium layer of trees but some live in stems of herbaceous plants or in seeds. Adults also feed on cambium but sometimes also on shoots. Some groups cultivate fungi in galleries (ambrosia beetles). Apparently a rare family in Bonanza.

Stylopidae (twisted-winged insects) 3 species. Wing covers greatly reduced, hind wings fan-like. Females larva-form as largely internal parasites of Hymenoptera, Homoptera. Larvae completely internal. Bonanza species found in leaf-hoppers.

Order DIPTERA (true flies) 47 families. Insects with one pair of wings)

Suborder NEMOTOCERA 10 families. Flies with many segmented antennae, the segments generally similar.

Tipulidae (crane flies) 8 species. Extremely elongated flies, often rather large with legs that break off readily (resemble daddy-long-legs with wings). Larvae (called leather-jackets) aquatic, semi-aquatic or in moist humus, mostly as scavengers. Adults most abundant in riparian areas in shady moist places.

Psychodidae (filter flies, moth flies) 3 species. Most species resemble tiny moths with wings held roof-like over body, densely hairy wings and body. Larvae of most species aquatic, attached to surfaces in contaminated water, sometimes in household drains. Adults near breeding areas, sometimes in houses. One group (sand flies) breed in drier crevices and holes, the adults biting at night and transmitting several tropical diseases. U.S. species (only one taken at Bonanza) not known to transmit diseases.

Culicidae (mosquitos) 5 species. Delicate, rather slender insects covered with scales, with long piercing-sucking beaks. Larvae aquatic in still or slow-moving water. Adults abundant along White River and Evacuation Creek, especially in June. Very few larvae found on or near sites; blow-in from distant areas suspected.

Ceratopogonidae (biting midges) 20 species. Minute gnats, often with short stabbing mouthparts, often with wing hairs forming pattern, usually rather compact for midges. Also known as punkies or no-see-ums. Larvae semi-aquatic in mud, wet sand, bottom debris, or moist humus. Adults of two genera (*Culicoides* and *Leptoconops*) very abundant and annoying during June and July, causing lumps and inflammation on scalp and face. Especially abundant in riparian areas but sometimes blown into upland areas as well. Adults of most other genera non-biting.

Chironomidae (midges) 26 species. Mosquito-like midges without wing scales or long ment parts. Mates with plumose antennae, females with long front legs. Larvae aquatic, usually in bottom debris. Some species oxygenate with haemoglobin. Adults often very abundant in riparian areas but non-biting.

Simuliidae (buffalo gnats or black flies) 2 species. Small compact flies with short legs, short but many segmented antennae, broad wings, stabbing mouth parts. Larvae very abundant in Evacuation Creek, attached to rocks in swift, shallow water. Adults at Bonanza bit animals other than man but often exceedingly annoying by swarming in front of human faces. Adults common to a mile or more from streams.

Mycetophilidae (fungus gnats) 6 species. Laterally compressed gnats with long, scarcely separated coxae, eyes well separated above antennae. Larvae feed in fungi. Adults stay near breeding places in damp, shady areas. Non-biting. At Bonanza, most abundant along White River, especially near overflow from water pump.

Sciaridae (dark-winged fungus gnats) 6 species. Resemble fungus gnats but more delicate with coxae less well developed,

with eyes meeting above. Larvae often very abundant in humus. Adults fly over breeding areas. Non-biting. Some species damage root hairs.

Scatopsidae (excrement midges) 3 species. Black, rather compact midges with short antennae, heavy anterior wing veins. Larvae predaceous in cow manure along White River. Adults stay close to surface of "cow pies."

Cecidomyiidae (gall midges) 16 species. Very delicate, rather elongated midges with long, beaded antennae, reduced venation. Larvae inducing formation of galls on many shrubs (leaves, stems, and fruit) or drilling in stems (for example, Hessian fly). Adults abundant in upland areas, usually associated with infested plants. Non-biting.

Suborder BRACHYCERA, 11 families. Antennae less than 5 segments but third sometimes annulate. Adult emerges from T-shaped opening in puparium.

Stratiomyidae (soldier flies) 4 species. Small to rather large dorsoventrally flattened flies with short discal wing cell subtending three open cells. Larvae aquatic (some) or in decaying cambium layer under bark. Adults on sunlit leaves or on flowers.

Tabanidae (horse flies, deer flies) 2 species. Larvae in aquatic muck. Large, robust flies, flattened dorsoventrally, with large often irridescently banded eyes. Antenna with terminal segmented style. Adults "vicious" biters of livestock and humans. Bonanza species extremely common and aggressive along White River.

Rhagionidae (snipe flies) 1 species. Medium-sized with long, tapering abdomen, rather round heads, scanty pubescence. Larvae predaceous in moist soil. Adults nectar feeders (some) or blood suckers on mammals (one genus, not yet collected at Bonanza).

Hilarimorphidae (hilarimorphid flies) 1 species. Small blackish flies with anal and discal wing cells open. Small family with unknown habits. Species at Bonanza taken in Malaise trap in upland ravine.

Therevidae (stiletto flies) 8 species. Medium-sized with long, usually pointed abdomen. Resemble asilids but head not excavated above. Predators in soil as larvae, nectar feeders as adults. Most common in upland areas.

Scenopinidae (window flies) 2 species. Small, dorsoventrally flattened flies with parallel sided abdomen, wings

attached posteriorly on thorax. Larvae predaceous on small insects in crevices and holes (dry situations). Adults often enter human enclosures and fly to windows. Moderately abundant in upland areas at Bonanza.

Mydidae (mydas flies) 1 species. Very large flies resembling asilids but with antennae clubbed. One rare species at Bonanza. Adults excellent mimics of tarantula hawk wasps. Larvae predators of large beetle larvae in soil.

Asilidae (robber flies) 22 species. Medium-sized to large, elongated flies with strong legs, long claws, excavation between eyes, strong, stabbing mouthparts. Adults capture, suck blood from other insects, larvae (very elongated) predaceous in soil.

Bombyliidae (bee flies) 64 species. Mostly stout-bodied, very hairy flies, often with long proboscis. Some species elongated, some very small without much hair. Head quite round on all species and readily detachable. Larvae parasitic on other larval insects (most) or predaceous on grasshopper egg masses (some). Adults suck nectar from flowers. Bonanza unusually rich in minute species, most of them in upland areas.

Empididae (dance flies) 18 species. Small flies with long, tapering abdomen, often hump-backed, with conspicuous terminal male genitalies. Predaceous in both stages, the larvae in soil or water. Adults often form mating swarms and are sometimes attracted to smoke.

Dolichopodidae (long-footed flies) 28 species. Small to minute, metallic-colored flies with long dorsal arista on antenna. Usually laterally compressed. Larvae semi-aquatic in mud and decaying vegetation. Largely predaceous. Adults predaceous on other insects and found near breeding places. Most abundant at Bonanza along White River, especially seepage areas and leakage or overflow from pumps.

Lonchopteridae (spear-winged flies) 1 species. Small, slender, yellowish flies with pointed wings and parallel veins. Larvae found in decaying vegetation. Adults commonly swept in moist, grassy situations.

Suborder CYCLORRHAPHA - 26 families. Antenna 3-segmented with dorsal arista. Adults emerge from circular opening in puparium.

Phoridae (phorid gnats) 7 species. Minute hump-backed flies with wing veins concentrated anterobasally. Most common around decaying plant and animal matter or associated with nests of ants, bees, wasps, or termites. Larvae may be

scavengers, fungus feeders, or parasites. Adults run with jerky movements.

Pipunculidae (big-headed flies) 6 species. Small flies with very large heads composed mainly of eyes. Wings narrowed basally. Larvae internal parasites of leafhoppers and related groups. Adults common around leafhopper habitats and sometimes on flowers.

Syrphidae (hover flies) 28 species. Large family of small to large flies with glistening wings possessing "spurious" or "false" vein anterior to discal cell. Flower visiting flies. Larval habits various - some scavengers in filthy substances (drone flies) some predators under bark, some predators on aphids, some pests on roots and bulbs. Many mimic bees or wasps. Commonest in upland areas.

Conopidae (thick-headed flies) 7 species. Medium-sized brownish flies with long antennae, long, usually elbowed proboscis. Often wasp-like. Adults nectar suckers, larvae internal parasites of bees and wasps. Most commonly encountered on sweet clover flowers along streams.

Otitidae (otitid flies) 12 species. Small to medium-sized flies, the wings usually pictured but subcostal vein not sharply bent. Larvae saprophagous, often in decaying fruit but sometimes attacking living plant tissue. Larvae of some species in soil, feeding on dead or dying insects. Adults (usually with pictured wings) found in both riparian and upland habitats.

Tephritidae (fruit flies, picture-winged flies) 19 species. Small to medium-sized flies with pictured wings and sharply bent subcostal vein. Oviposit in healthy plant tissue. Larvae of some mine leaves, others form galls, many develop in fruit, young seeds, flower ovaries. Many Bonanza species develop in composite heads. Most common in upland areas.

Sepsidae (black scavenger flies) 2 species. Small, shining black flies with spherical head, basally narrowed abdomen. Many with dark spot near wing tips. Larvae in decaying animal or vegetable material (excrement, carrion, etc.). At Bonanza, adults common around "cow pies" in moist places along White River.

Sciomyzidae (snail flies, marsh flies) 1 species. Small to medium-sized flies with head produced forward, antennae directed forward. Wings usually pictured. Larvae parasitic in freshwater snails. Species at Bonanza taken as adults in wet meadow around overflow from water pump near White River.

Lauxaniidae (lauxaniid flies) 3 species. Small, rather robust flies with complete subcostal cell, no oral vibrissae. Inhabit damp, shady situation as under cottonwood trees along White River. Larvae saprophagous in decaying vegetation.

Chamaemyiidae (aphid flies) 5 species. Small flies, usually light grey with black spots on abdomen. Larvae are predators of aphids, scales, and mealy bugs. Adults fly around host plants of host insects. Most common at Bonanza in upland areas.

Lonchaeidae (lonchaeid flies) 3 species. Small shining black flies with oval, abruptly pointed abdomen. Larvae saprophagous under bark, in decaying fruit, exuding sap. Adults of species at Bonanza commonly found on cottonwood trees at White River.

Sphaeroceridae (manure flies) 3 species. Very small blackish flies with long head bristles, short broad first tarsal segment of hind leg. Larvae scavengers in excrement, decaying vegetation. Extremely common in "cow pies" at Bonanza. Adults stay close to larval habitat.

Tethinidae (tethinid flies) 4 species. Adults commonest in moist grassy areas along White River. Adult and larval habits for this family are unknown but they are always associated with salty or alkaline conditions.

Milichiidae (milichiid flies) 8 species. Small flies, usually black or silvery, often with milky wings. Larvae - saprophagous or coprophagous. In Bonanza, adults taken by sweeping various shrubs, mostly near White River and Evacuation Creek.

Carnidae (carnid flies) 4 species. Small to minute black flies with head small and round in profile. Larvae often carnivorous on nestling birds. Adults usually on flowering shrubs.

Chryomyidae (chyromyid flies) 1 species. Small larvae of some species breed in bird's nests. Adults often enter human dwellings or autos and fly to windows.

Psilidae (rust flies) 1 species small, slender flies with long antennae, with wings weakened across basal third. Larvae live in roots, tubers, bulbs, etc. on fleshy stalks. Only one adult specimen taken at Bonanza (by Evacuation Creek).

Micropezidae (stilt-legged flies) 1 species medium-sized elongate flies with stilt-like legs. Larvae of most species

breed in excrement. Adults in moist, shady situations. Species at Bonanza collected in willows along White River.

Ephydridae (shore flies, brine flies) 34 species. Small to very small dark colored flies, usually with very swollen elgpens, large oral cavity. Larvae aquatic or semi-aquatic, some mining leaves in emergent vegetation. Some extremely abundant in saline waters. Adults found on emergent plants, mud flats, or skating on water. One group predaceous, with raptorial legs. At Bonanza, most common in damp places along White River.

Drosophilidae (pomace flies, minute fruit flies) 4 species. Small, usually yellowish flies with wing margin broken at junction with united subsosta and Ri. Larvae of most feed on micro-organisms in rotting fruit, vegetation, and fungi; a few ectoparasitic or predaceous on other insects. Adults usually taken around damp, decaying vegetation or spoiling fruit.

Chloropidae (frit flies, eye gnats) 41 species. Small to minute flies, nearly always with polished triangle surrounding ocelli. Adults usually found in low vegetation, especially in moist habitats. Larval habits varied - some phytophagous as stem borers or gall formers, other saprophagous, one group (*Thaumatomyia*) a predator on root aphids. Adults of one genus (*Hippelates*) annoying around eyes, other facial parts. In Bonanza, most abundant in wet meadow formed by water pump overflow near White River crossing.

Agromyzidae (leaf-mining flies) 29 species. Small blackish or yellowish flies with pale cheeks. Larvae of most species mine plant leaves, usually host specific. Adults usually associated with larval host plants. Common in riparian and upland areas.

Trixoscelidae (trixoscelid flies) 7 species. Small flies with orange or light brown frons bordered laterally with light tan. Biology generally unknown. Adults associated with shrubs in upland areas at Bonanza.

Anthomyzidae (anthomyzid flies) 2 species. Small, rather elongate flies, often with pictured wings. Larvae apparently phytophagous in stems of marsh plants. Adults around marshy places in low vegetation.

Asteiidae (asteid₂³flies) 3 species. Small to minute flies with wing veins R^{2+3} ending in costa next to R^1 . Biology unknown. Adults at Bonanza common on flowers of sweetclover and tamarix.

Anthomyiidae (anthomyiid flies, root maggots, dung flies, etc.) 26 species. Mostly medium-sized flies close to muscids but anal vein reaches wing margin. Larval habits extremely varied in different genera - leaf-miners, dung maggots, root and bulb maggots, some aquatic in muck. Adults usually associated with shade, moist places. Most common species in Bonanza (*Scatophaga stercoraria*) breeds in "cow pies" and adult is predaceous on insects flying about them.

Muscidae (house flies, stable flies, horn flies, etc.) 25 species. Medium-sized flies resembling anthomyiids but anal vein not reaching wing margin. Closely related to anthomyiids. Larval habits equally varied - phytophagous, scatophagous, saprophagous, zoophagous, etc. Adults predaceous or flower-visiting or zoophagous (feeding on animal blood or exudates) or scatophagous. Several species at Bonanza associated with livestock. One genus (*Lispe*) commonly seen running on mud or water along stream margins.

Calliphoridae (blow flies, bottle flies, screw worms, etc.) 8 species. Medium-sized to large flies, usually metallic colored, with antennal arista plumose to tip. Larvae omnivorous, carnivorous, or in some cases parasitic. Commonest species found around carrion, excrement, garbage. At Bonanza some associated with nestling birds, the maggots sucking blood.

Sarcophagidae (flesh flies, etc.) 30 species. Small to large flies, thorax dark with grey stripes (never metallic). Larval habits varied; many feed on carrion, some endoparasites of other insects, many feed on prey or stored pollen of wasps and bees. Adults common flowers in upland and riparian areas.

Tachinidae (tachina flies) 75 species. Small to large flies with very prominent postscutellum and usually strongly bristled abdomen. The largest family of flies, all endoparasitic as larvae on other insects. Adults generally feed on nectar. Most species uncommon at Bonanza but few abundant on flowers such as *Clematis*, *Chrysothamnus*, etc.

Order HYMENOPTERA (wasps, bees, ants, sawflies, etc.) 39 families

Suborder CHALASTOGASTRA - Primitive groups with legged, phytophagous larvae, adults with abdomen broadly joined to thorax.

Tenthredinidae (sawflies) 2 species. Large family. Medium-sized somewhat dorsoventrally flattened, short ovipositor.

Larvae feed on leaf surfaces (some) or make stem galls. Adults mostly feed on pollen and nectar. Bonanza species on willows along White River.

Braconidae (braconid wasps) 88 species. Large family of usually small, slender, delicate wasps with long antennae, only one recurrent wing vein. Forewing lacks "areolet". Larvae internal parasites of other insects but often pupate externally on host.

Ichneumonidae (ichneumon flies) 59 species. Large family of slender wasps with long antennae (usually larger than braconids). Wings with 2 recurrent veins, usually with at least partial "areolet". Larvae mostly internal parasites of other insects (sometimes external on insects in cocoons).

Mymaridae (fairy wasps) 7 species. Adults extremely small, delicate with feathery wings. Larvae develop in insect eggs, especially Homoptera.

Trichogrammatidae (egg-parasite wasps) 3 species. Adults extremely small and compact, probably smallest of all insects. Larvae develop in insect eggs, especially Lepidoptera.

Eulophidae (eulophid wasps) 65 species. Large family of small, often delicate chalcidoids, usually with 4-segmented tarsi. The larvae parasitic on wide variety of insects, especially Hemiptera (homoptera), Diptera, Hymenoptera. Adults found around host plants of adults, less commonly taking nectar from flowers.

Elasmidae (elasmid wasps) ___ species. Minute wasps, strongly compressed laterally, otherwise resembling eulophids in having straight fore-tibial spur. Larvae of all species internal parasites of other insects.

Thysanidae (thysanid wasps) 1 species. Minute, black short-bodied chalcids. Parasitic primarily on scale insects and whiteflies. Only one specimen collected at Bonanza.

Eutrichosomatidae (eutrichosomatid wasps) 1 species. Adults sparsely covered with white scale-like hairs. Only 2 species in North America, one parasitic on weevils. Species in Bonanza taken on *Juniperus* in upland areas.

Encyrtidae (encyrtid wasps) 25 species. Usually moderately robust but rather small chalcidoids with scutellum unusually prominent. Larvae parasitic on wide variety of insects but especially Homoptera.

Eupelmidae (eupelmid wasps) 5 species. Adults (generally uncommon) with sway-backed appearance. Larvae parasitic on

many insects but especially Coleoptera. Adults swept from *Juniperus* at Bonanza.

Eucharitidae (eucharitid wasps) 1 species. Larvae parasitic in ant larvae. Adults bright metallic, often ornate. Bonanza species taken on aphid secretions in Southam Canyon.

Perilampidae (perilampid wasps) 3 species. Adults robust, brilliantly metallic, nectar feeders. Larvae parasitic in many insects but especially Neuroptera, Lepidoptera, hymenopterous parasites of Lepidoptera.

Torymidae (torymid wasps) 17 species. Adults metallic with long ovipositors, often nectar feeding. Larvae parasitic on many insects especially Hymenoptera but 2 genera phytophagous, one in *Ficus* the other in plant seeds.

Pteromalidae (pteromalid wasps) 71 species. Rather robust, usually submetallic with short ovipositor, usually 5-segmented torsi. Larvae parasitoids of wide variety of insects. Some are host specific, others wide ranging. Adults of most species visit flowers, in Bonanza, especially *Chrysothamnus*, *melilotus*.

Eurytomidae (seed chalcids, joint worms, etc.) 16 species. Adults generally non-metallic with prominent prothorax. Some larvae develop in seeds, others in grass stems, others in plant galls (feeding on tissues of galls and gall-makers), other insects parasitoids only. Usually found in association with grasses, legume seeds, or plant galls at Bonanza, most commonly in upland areas.

Chalcididae (true "chalcisflies") 8 species. Large for chalcidoids, with enlarged hind femora. Larvae parasitic on wide variety of insects but especially Coleoptera, Hymenoptera. Many hyperparasites. Adults of most species feed on nectar.

Leucospidae (leucospid wasps) 1 species. Adults large, vespid wasp-mimicking forms with long ovipositors directed forward over their heads. Larvae parasitic on larvae of leaf-cutting bees.

Superfamily *Cynipoidea* (gall wasps, etc.) 12 species. Usually robust, laterally compressed, polished with venation reduced but less so than in chalcidoids. Most species phytophagous gall-making forms (especially on oak) but those at Bonanza apparently parasitic.

Figitidae (figitid wasps) 4 species. First metasomal tergum shorter than second. Larvae parasites of pupal insects, especially Dipter and Neuroptera. Commonest species at Bonanza frequently seen on "cow pies" by White River (parasite of blow flies, etc.).

Cynipidae (gall wasps) 10 species. First metasomal tergum longer than second. Best known as oak gall formers but our species parasitic on dipterous puparia.

Superfamily *Evanioidea*. Ensign wasps, etc. Abdomen attached high above hind coxa. All parasitic.

Gasteruptiidae (long-necked wasps) 1 species. Slender wasps with long neck, abdomen set high on thorax. Larvae parasitic on larvae of bees (usually *Hylaeus*). Adults commonly collected on vertical clay banks harboring hosts.

Superfamily *Proctotrupoidea* (proctotrupoid wasps) Venation usually as reduced or nearly so as chalcidoids but ovipositor terminal. A large, diverse, poorly known superfamily, all parasitoids of other insects.

Proctotrupidae (proctotrupid wasps) 1 species. Rather large for proctotrupoids, laterally compressed, with several prominent veins in posterior half of forewing. Often abundant but habits nearly unknown. A few known to be parasitic on Coleoptera. Adults at Bonanza taken in Malaise traps.

Ceraphronidae (ceraphronid wasps) 5 species. Wing vein proceeding from stigma forming prominent loop. Mostly minute, little known, often wingless, inhabiting soil litter. Wide variety of host insects, including dipterous pupae, aphids, ants, braconid wasps, etc. At Bonanza, collected mainly on shrubs in upland areas.

Diapriidae (diapriid wasps) 2 species. Slender, with antennae arising from shelf in front of head. Small, little known insects, apparently mostly parasitoids of Diptera but some of ants. Adults at Bonanza were mostly collected in moist areas along White River and Evacuation Creek.

Scelionidae (scelionid wasps) 15 species. Mostly minute wasps parasitizing the eggs of other insects, especially Hemiptera, Coleoptera, Neuroptera, and Orthoptera. Common in sweepings of shrubs.

Platygasteridae (platygasterid wasps) 8 species. Minute black wasps with very reduced venation, antennae extremely low on face. Parasitize mainly Diptera, mealybugs and whiteflies.

Superfamily *Chrysidoidea* (cuckoo wasps) 23 species.

Chrysididae (cuckoo wasps) 22 species. Robust wasps of brilliant metallic hues, not more than 3 visible abdominal segments. Parasitic mainly on nesting Hymenoptera

but a few on Lepidoptera. On Hymenoptera, larvae of most forms develop in host prepupae but a few on prey taken into nest by host. Adults commonly collected on flowers or searching for host nests, usually in semi-arid areas.

Bethylidae (Bethylid wasps) 6 species. Small, black polished wasps parasitic on other insects, especially Coleoptera. Adults seldom fly, inhabit soil litter, occasionally low vegetation. Frequently taken in Malaise traps.

Dryinidae (dryinid wasps) 1 species. Highly specialized parasitoids of Homoptera, especially leafhoppers, plant hoppers. Females of many species wingless.

Superfamily *Scolioidea* (scolioid wasps, velvet ants, ants, etc.) 56 species.

Tiphiidae (tiphiid wasps) 7 species. Medium sized wasps, usually black, diurnal forms with oval or elongate kidney-shaped eyes. Mostly parasitic on them. On subterranean coleopterous larvae which they paralyze before ovipositing on them. Adults of most forms visit flowers but one subfamily nocturnal with wingless females.

Mutillidae (velvet ants) 29 species. Mostly medium sized wasps, usually very hairy with wingless females; parasitic on nesting Hymenoptera. Most species squeak. Composed of diurnal and nocturnal species, none of them flower visiting but sometimes attracted to aphid honeydew. Round eyes.

Scoliidae (scoliid wasps) 1 species. Large wasps, the mid legs separated widely by large plate formed of fused mesosternum and metasternum. Larvae ectoparasitic on scarabaeid beetle larvae. Largely tropical or subtropical in distribution. Adults of our species moderately common on *Chrysothamnus*, *Melilotus* and *Tamarix*.

Sapygidae (sapygid wasps) 1 species. A small family of rather slender wasps with dorsum and venter of abdomen similar in appearance. Most members cuckoo-like parasites of megachilid or xylocopid bees. Ours, a parasite of the alfalfa leaf-cutting bee among other megachilids.

Formicidae (ants) 18 species. Large family distinguished by prominent upright lobe on pedicel of abdomen and by very long first antennal segment. Social insects with colonies commonly in the soil or decaying wood. Some general feeders but others with highly specialized food habits. Often dominant forms with strong effects on populations of many other insects.

Superfamily *Vespoidea* (vespoid wasps) 54 species.

Vespidae (paper wasps) 4 species. Usually large wasps with forewings longitudinally folded at rest. Midtibia with 2 apical spurs, body with silky texture, claws unclt. Larvae fed wide assortment of proteinaceous food including insects, meat scraps. Adults feed on nectar, fruit juices meat exudates.

Pompilidae (spider wasps) 31 species. Somewhat laterally compressed, with large coxal, long leg spines, sleek appearance imparted by satiny pubescence. Solitary wasps provisioning their nests with spiders. Most species nest below ground. One genus a "cuckoo" parasite of others. Adults usually collected on flowers or searching for appropriate spider prey.

Superfamily *Sphecoidea* (sphecoid wasps) 110 species. Most belong to 1 family.

Sphecidae 110 species. Large, diverse family, the pronotum widely separated from tegula and without plumose hairs on body. Each genus usually provisioning nest with narrow spectrum of insect prey. Generally most abundant in semi-arid areas. Adults primarily nectar-feeding.

Superfamily *Apoidea* (bees) 139 species. Usually robust insects with most body hairs plumose, with broad first hind tarsal segment. All provision nests with nectar and pollen or have "cuckoo" relationship with other bees.

Colletidae ("celophane" bees) 9 species. Solitary bees that construct brood cells of transparent, waxy material. One subfamily in Bonanza area constructs own burrows in soil, the other uses small pre-existing cavities in many situations.

Andrenidae (mining bees) 33 species. All species solitary, construct own nests in soil. Most species with narrow spectrum of pollen sources. Most prefer semi-arid areas.

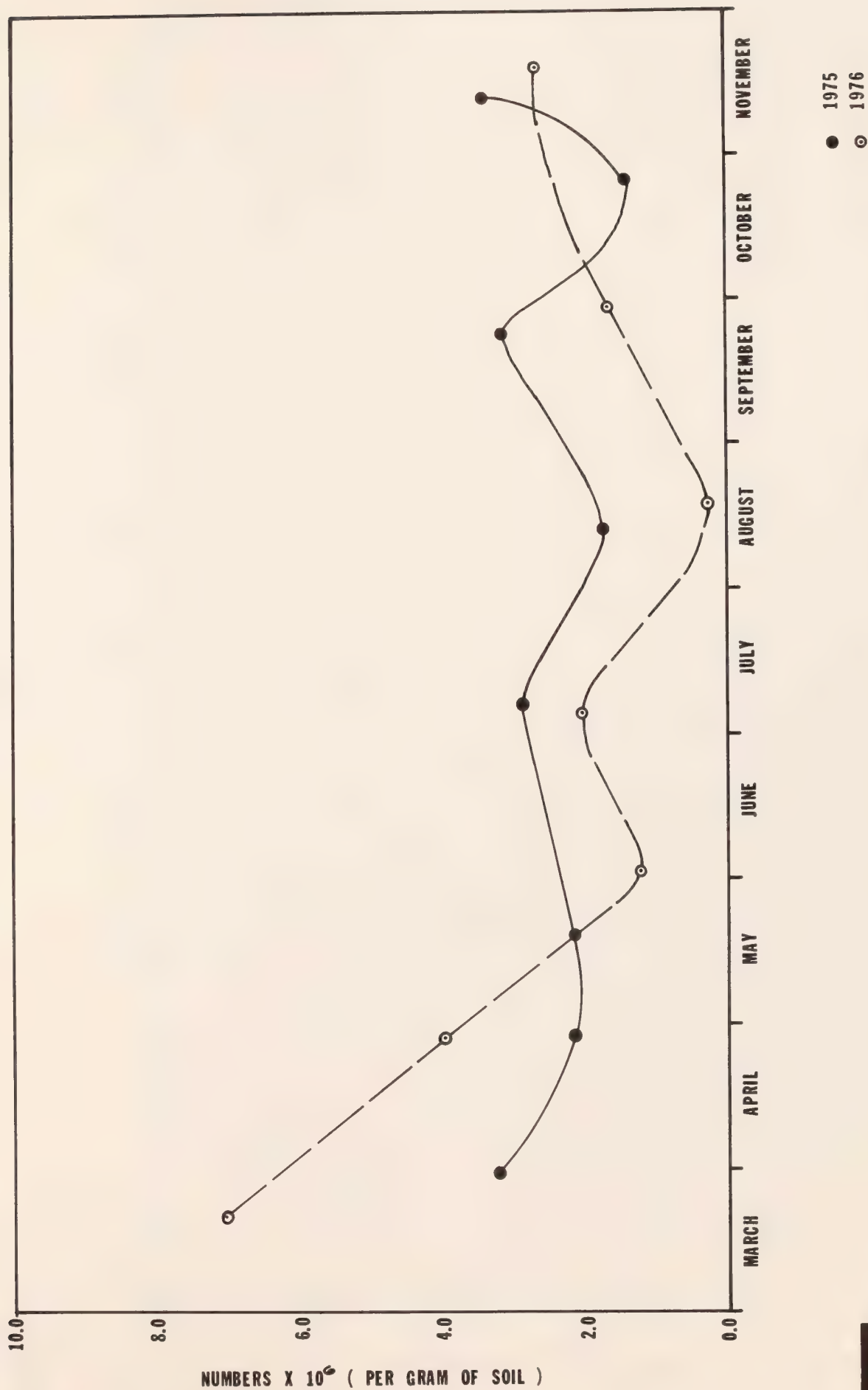
Haliotidae (sweat bees) 31 species. Most are subsocial or semi-social and construct burrows in soil or decaying wood. Many species have wide pollen host range.

Anthophoridae (flower bees) 29 species. A large, diverse family with diverse nesting habits. All species essentially solitary. Many with "cuckoo" relationships

with other bees. Nests of most species in soil but nests of one subfamily (xylocopinae) primarily in wood or pithy stems.

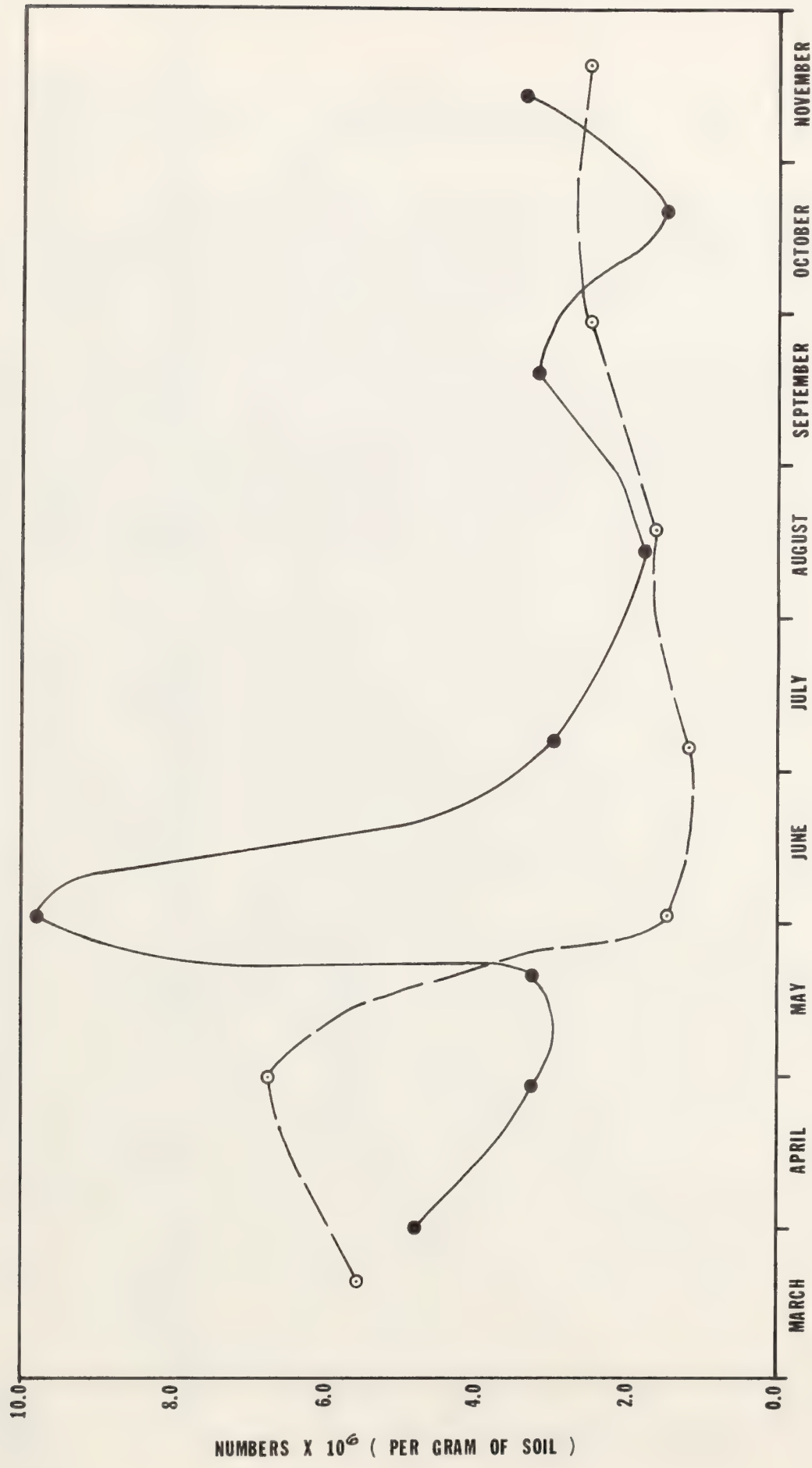
Megachilidae (leafcutting bees, cotton bees, resin bees, etc.) 33 species. Bees that carry pollen on abdominal scopa and use foreign materials (often of plant origin) to construct brood cells. Most species use pre-existing cavities. Carry pollen on abdominal scopa.

Apidae (honey bees, bumble bees, etc.) 3 species. Pollen carried on concave, polished surface of hind tibia. Mostly social bees nesting in large cavities and using wide spectrum pollen and nectar hosts. Cells constructed of secreted wax, sometimes mixed with materials of plant origin. A few species with "cuckoo" relationship with other related bees. Honey bees and bumble bees at Bonanza most abundant in riparian areas.



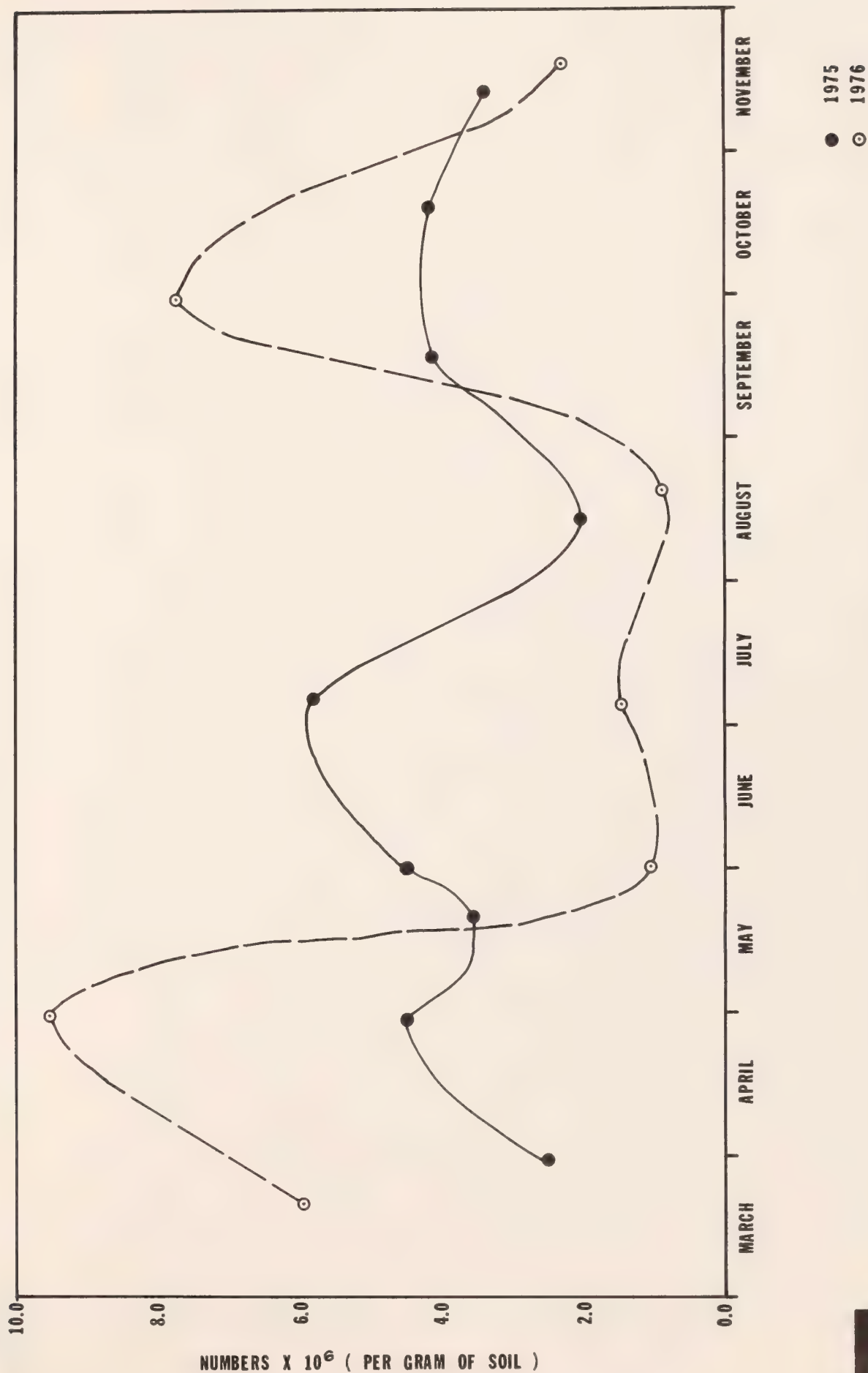
NUMBERS OF AEROBIC BACTERIA FOR 1975 AND 1976 SAMPLING DATES





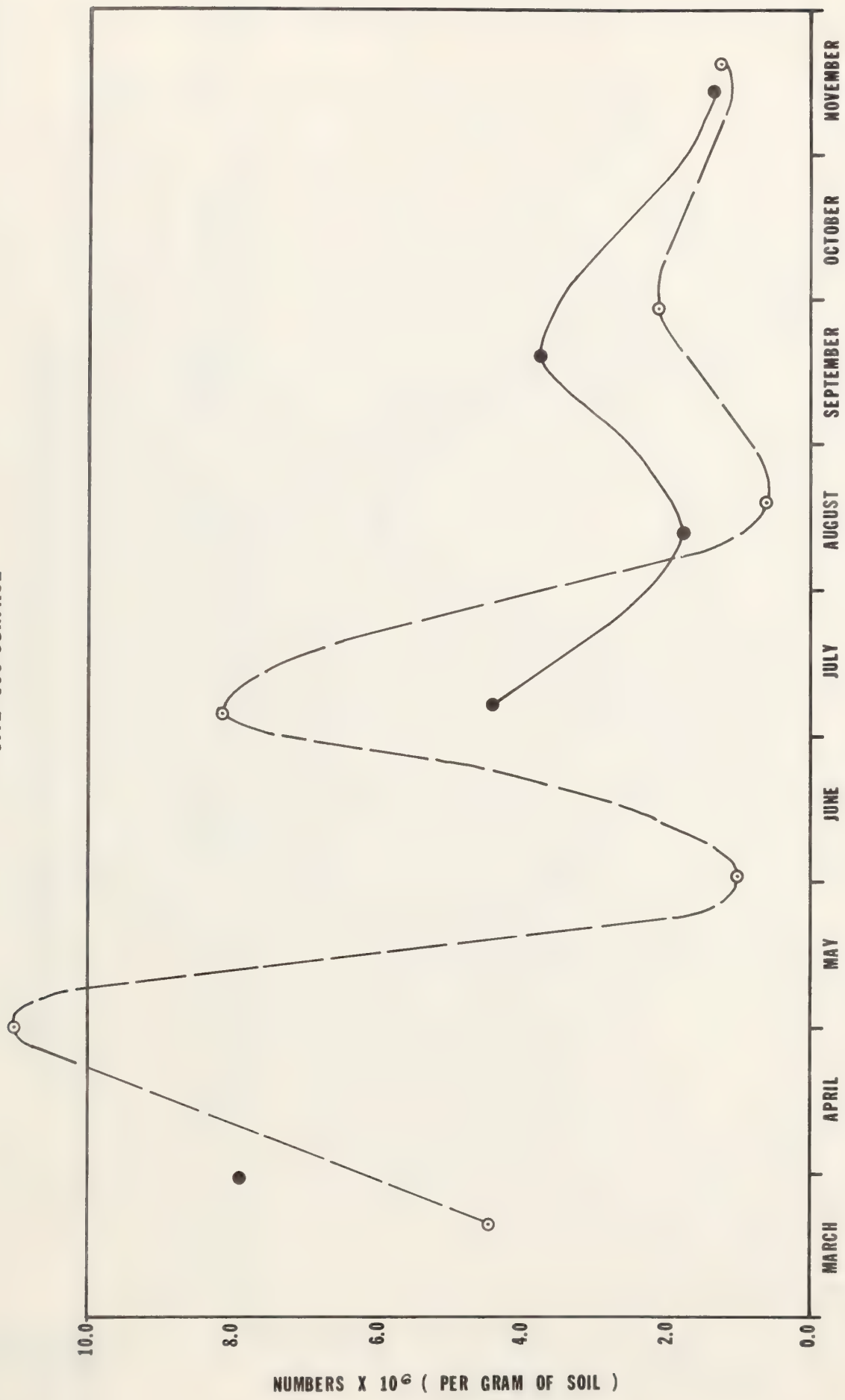
NUMBERS OF AEROBIC BACTERIA FOR 1975 AND 1976 SAMPLING DATES





NUMBERS OF AEROBIC BACTERIA FOR 1975 AND 1976 SAMPLING DATES

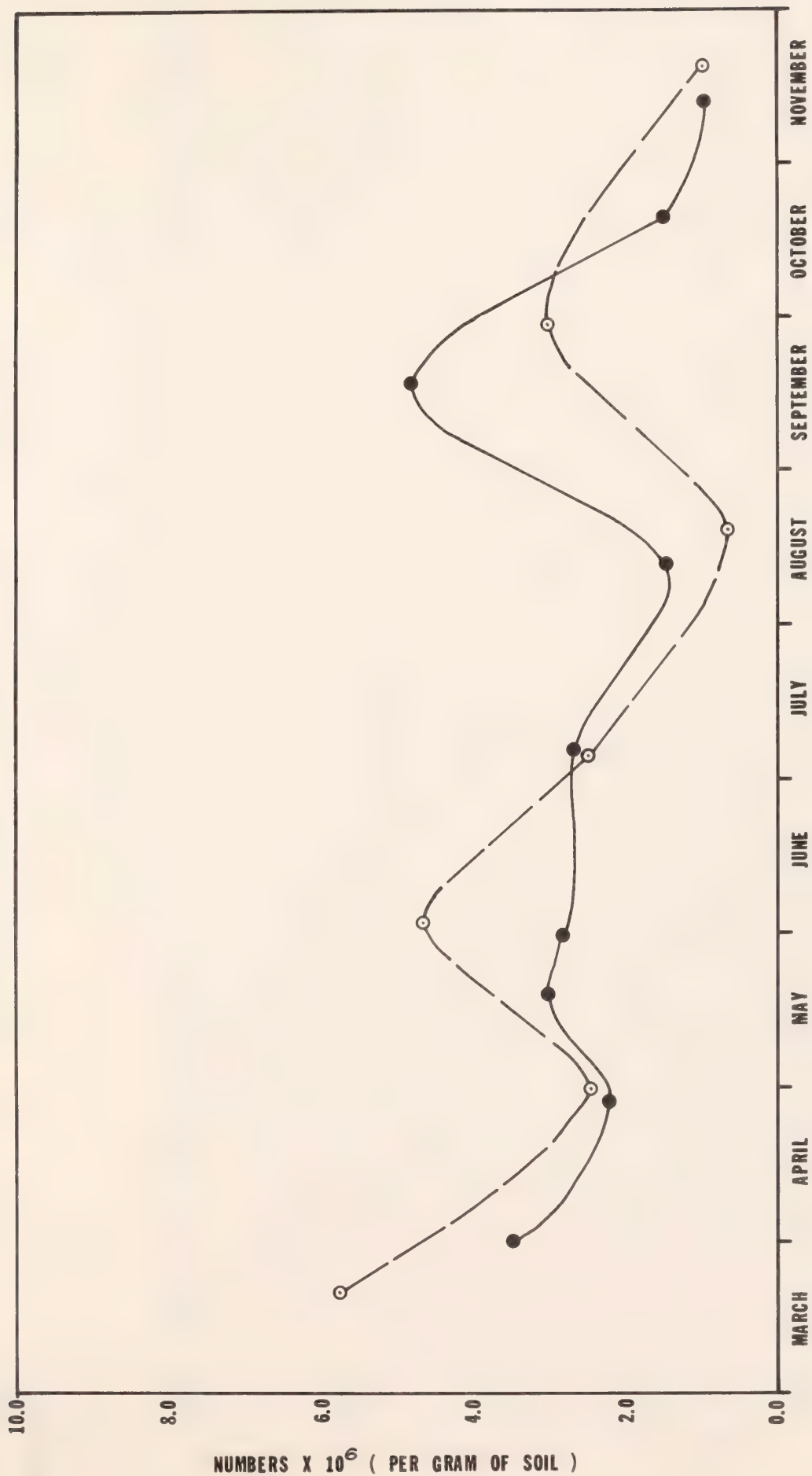




● 1975
○ 1976

NUMBERS OF AEROBIC BACTERIA FOR 1975 AND 1976 SAMPLING DATES





● 1975
○ 1976

NUMBERS OF AEROBIC BACTERIA FOR 1975 AND 1976 SAMPLING DATES

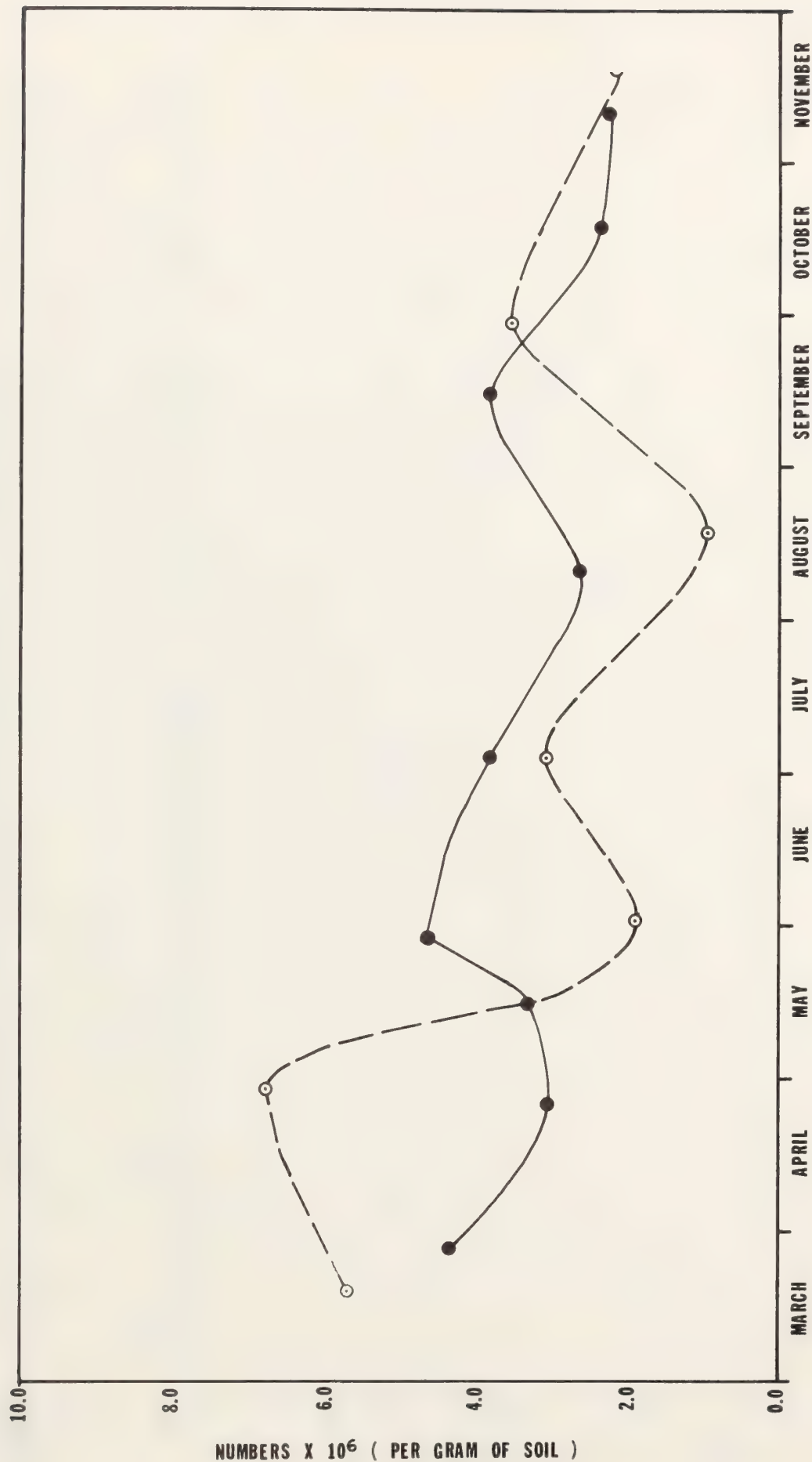


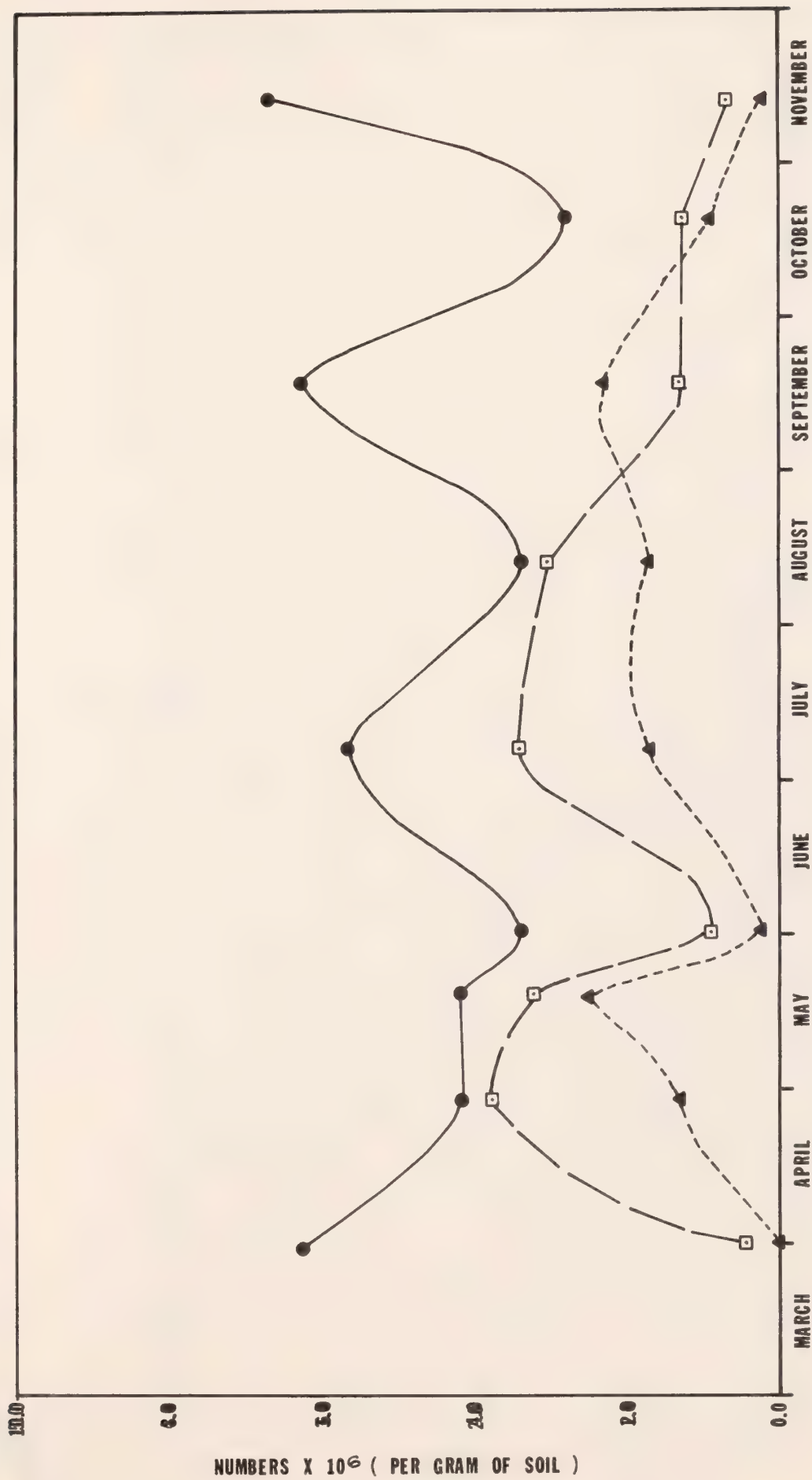
MEAN VALUES FOR ALL SITES OF NUMBERS OF AEROBIC BACTERIA FOR 1975 AND 1976 SAMPLES

● 1975
○ 1976

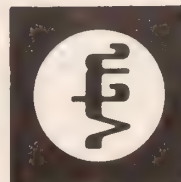


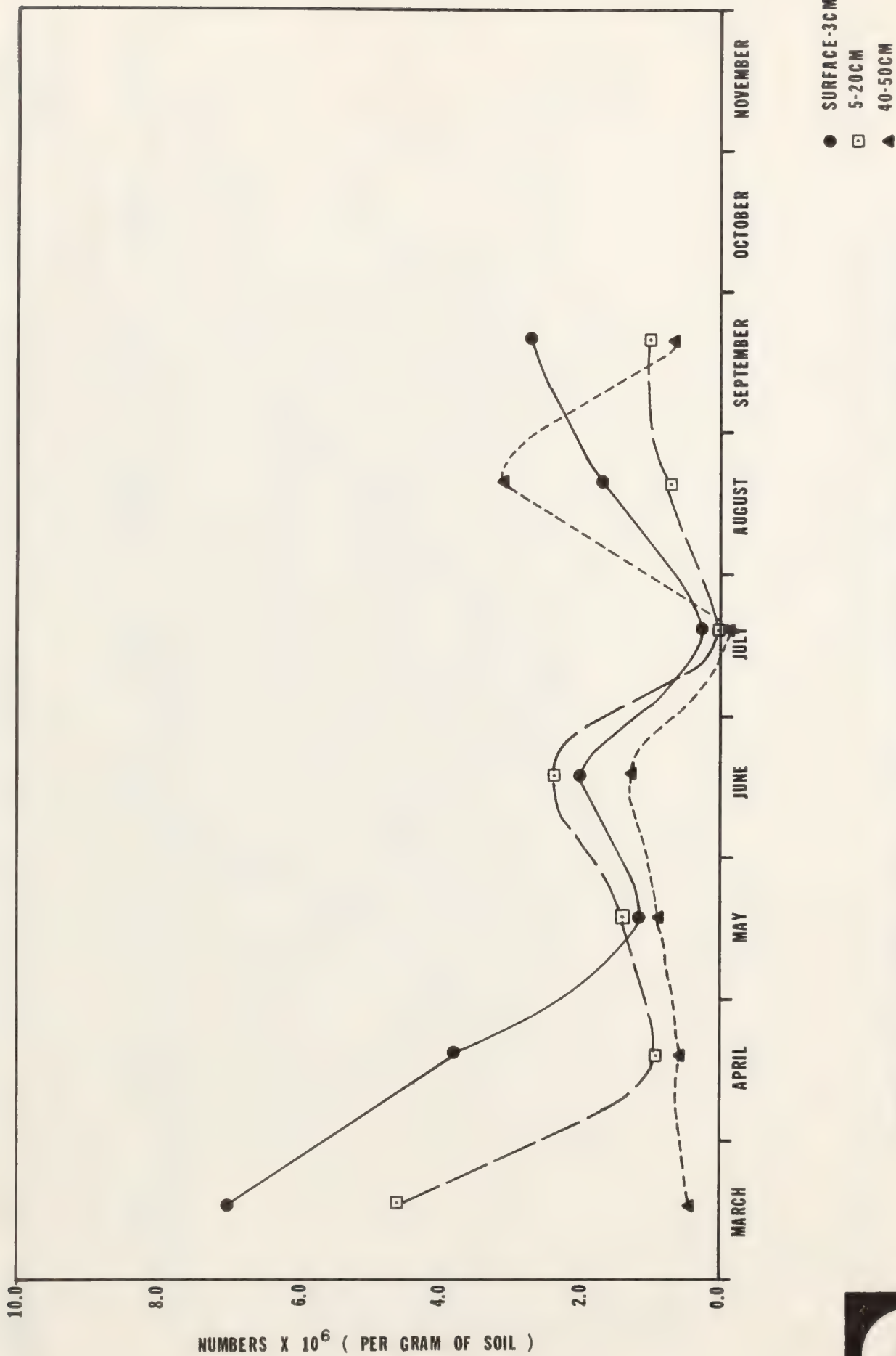
SURFACE





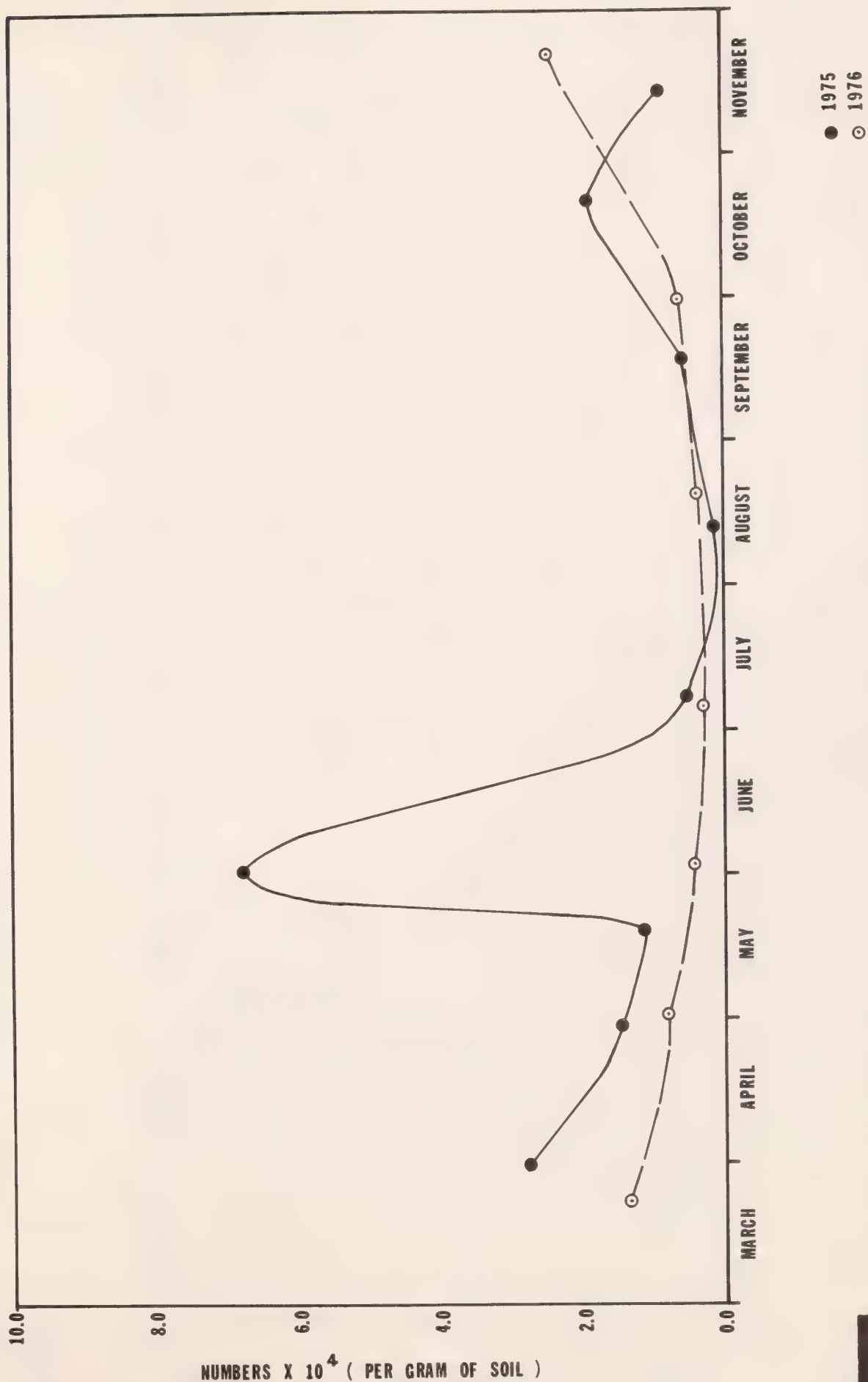
NUMBERS OF AEROBIC BACTERIA AT THREE DIFFERENT DEPTHS FOR 1975 SAMPLING DATES



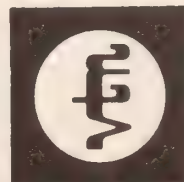


NUMBERS OF AEROBIC BACTERIA AT THREE DIFFERENT DEPTHS FOR 1976 SAMPLING DATES





NUMBERS OF ANAEROBIC BACTERIA FOR 1975 AND 1976 SAMPLING DATES





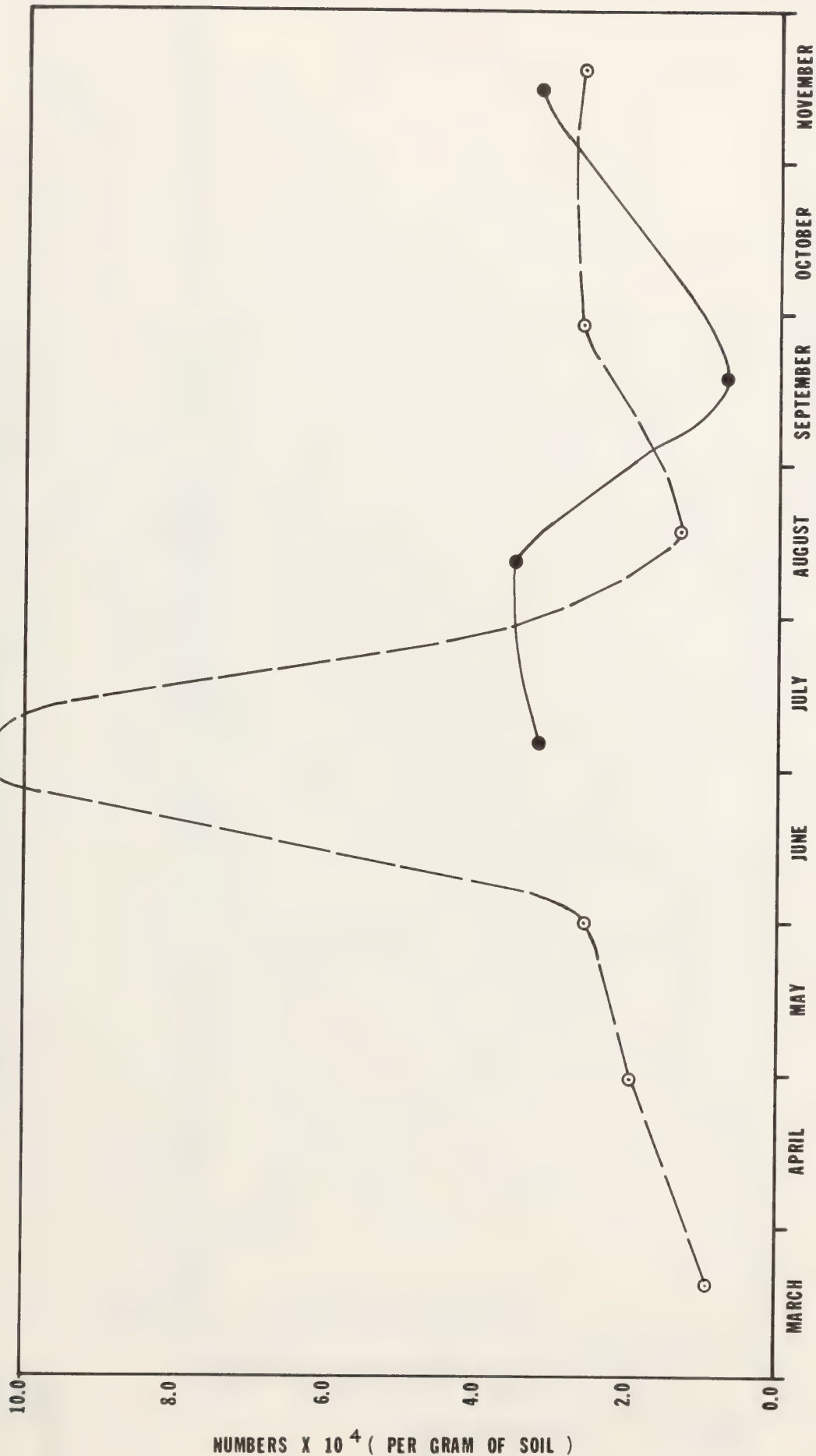
NUMBERS OF ANAEROBIC BACTERIA FOR 1975 AND 1976 SAMPLING DATES

APPENDIX IV-20

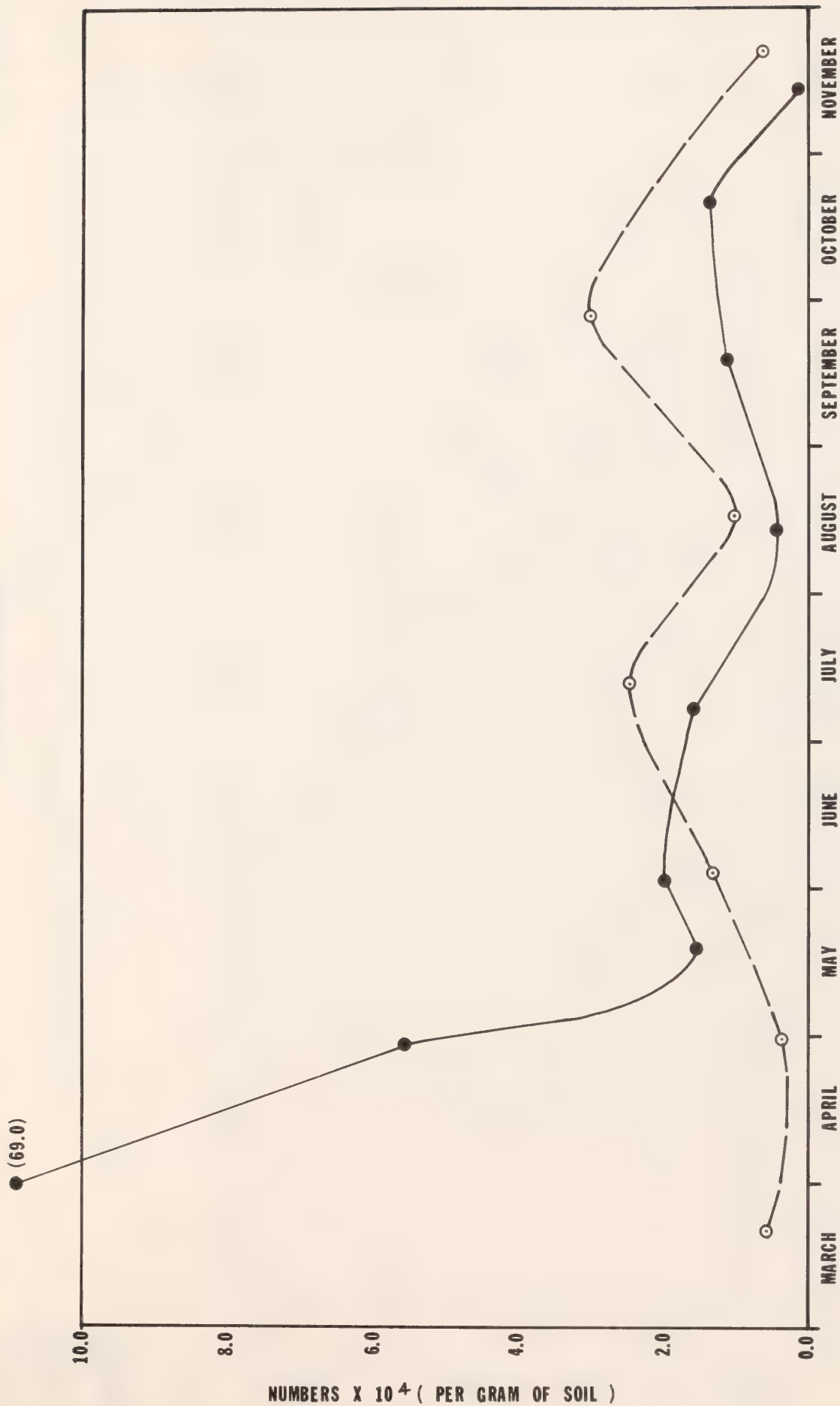
SITE 58C-SURFACE

● (40.0)

○ (11.6)



SITE 50JI-SURFACE

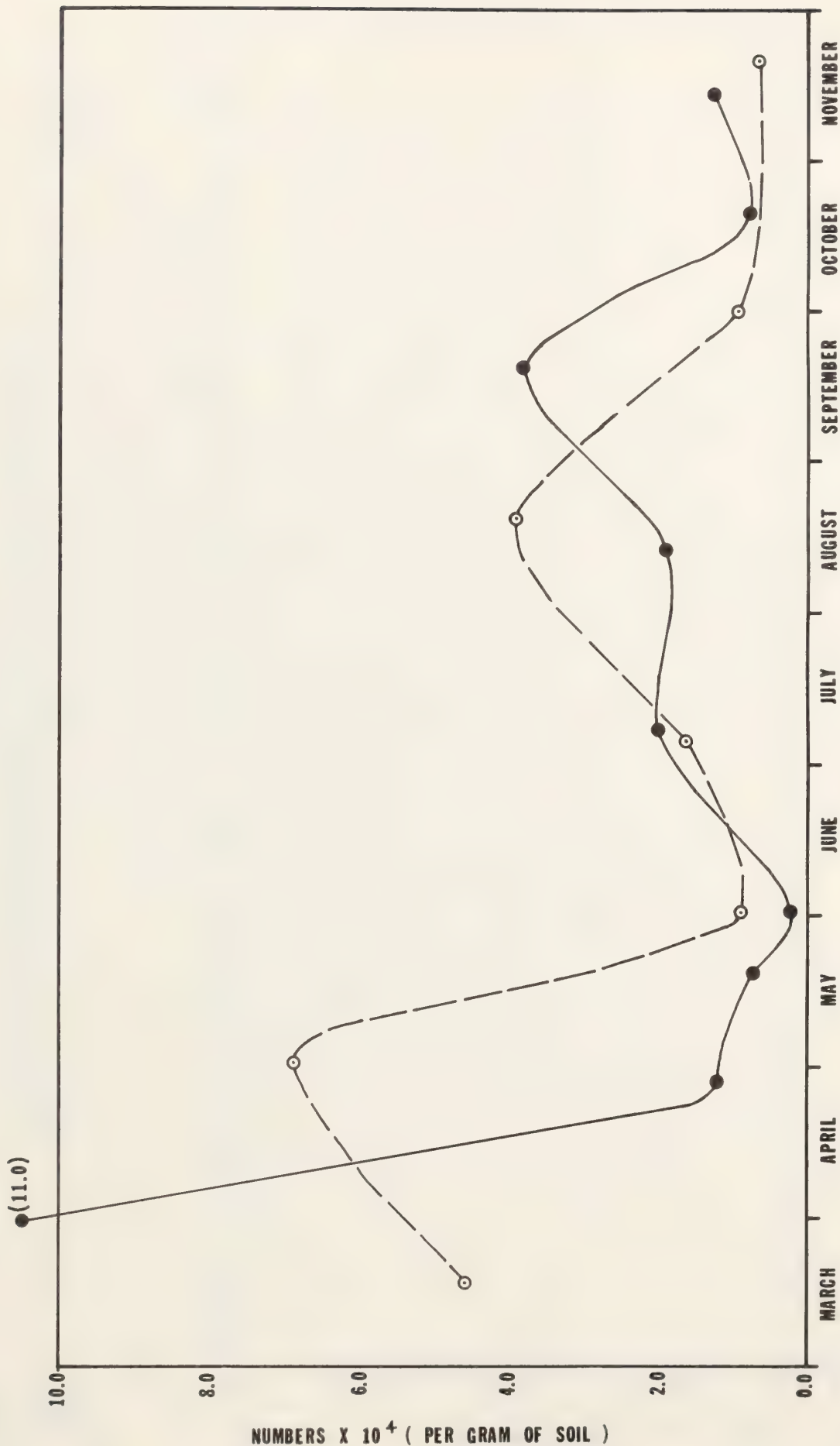


● 1975
○ 1976

NUMBERS OF ANAEROBIC BACTERIA FOR 1975 AND 1976 SAMPLING DATES

APPENDIX IV-21

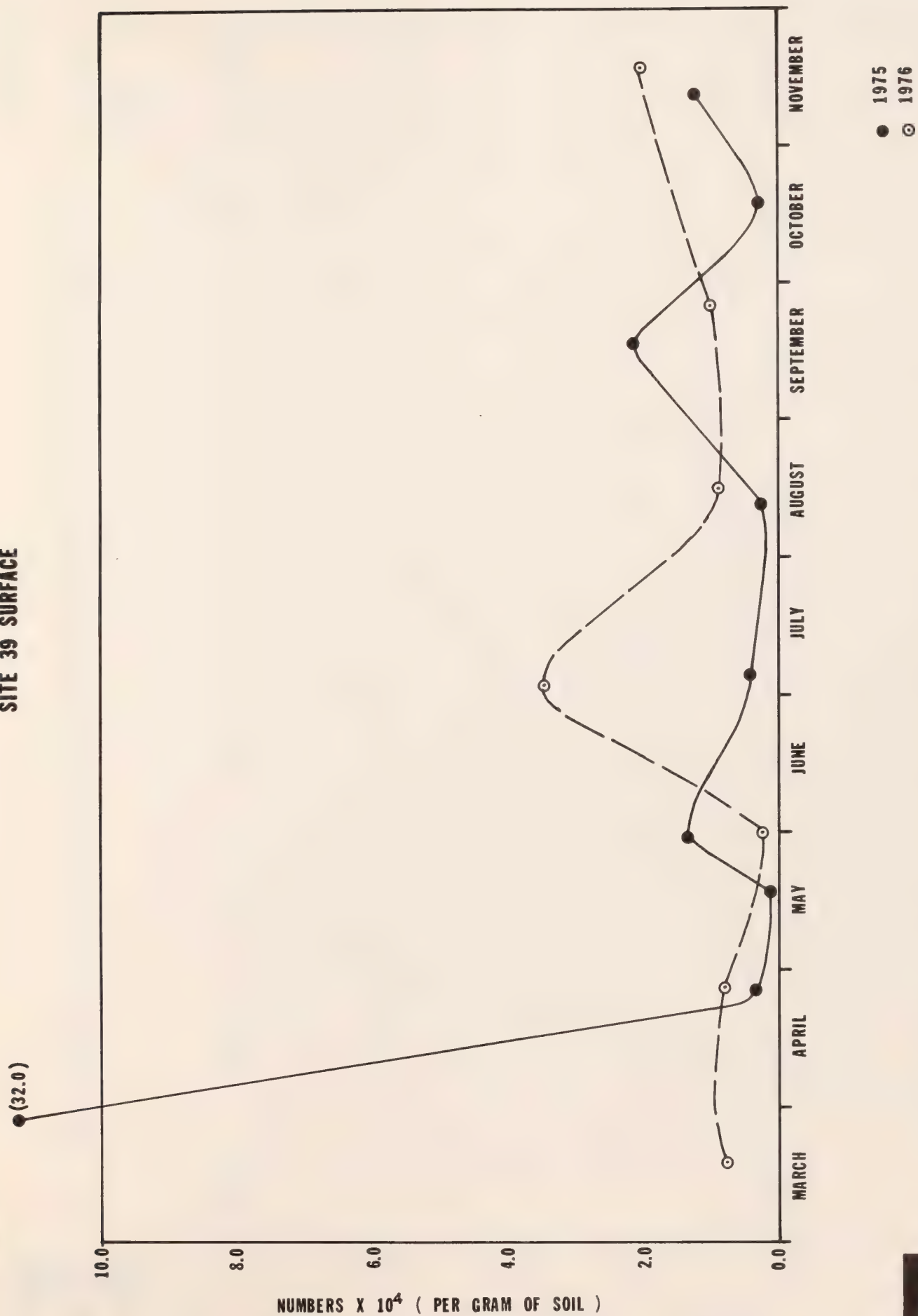




NUMBERS OF ANAEROBIC BACTERIA FOR 1975 AND 1976 SAMPLING DATES



SITE 39 SURFACE



NUMBERS OF ANAEROBIC BACTERIA FOR 1975 AND 1976 SAMPLING DATES

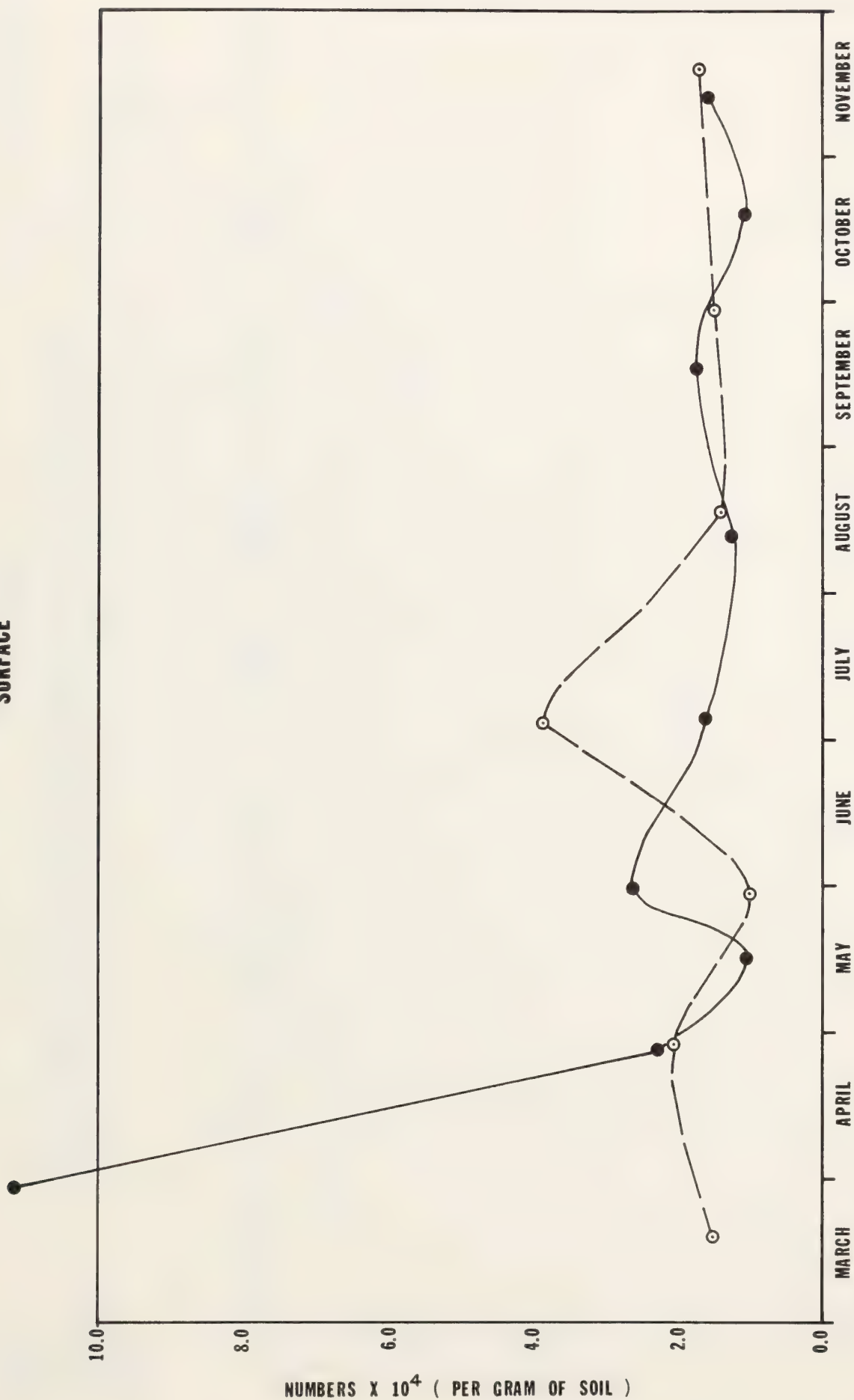


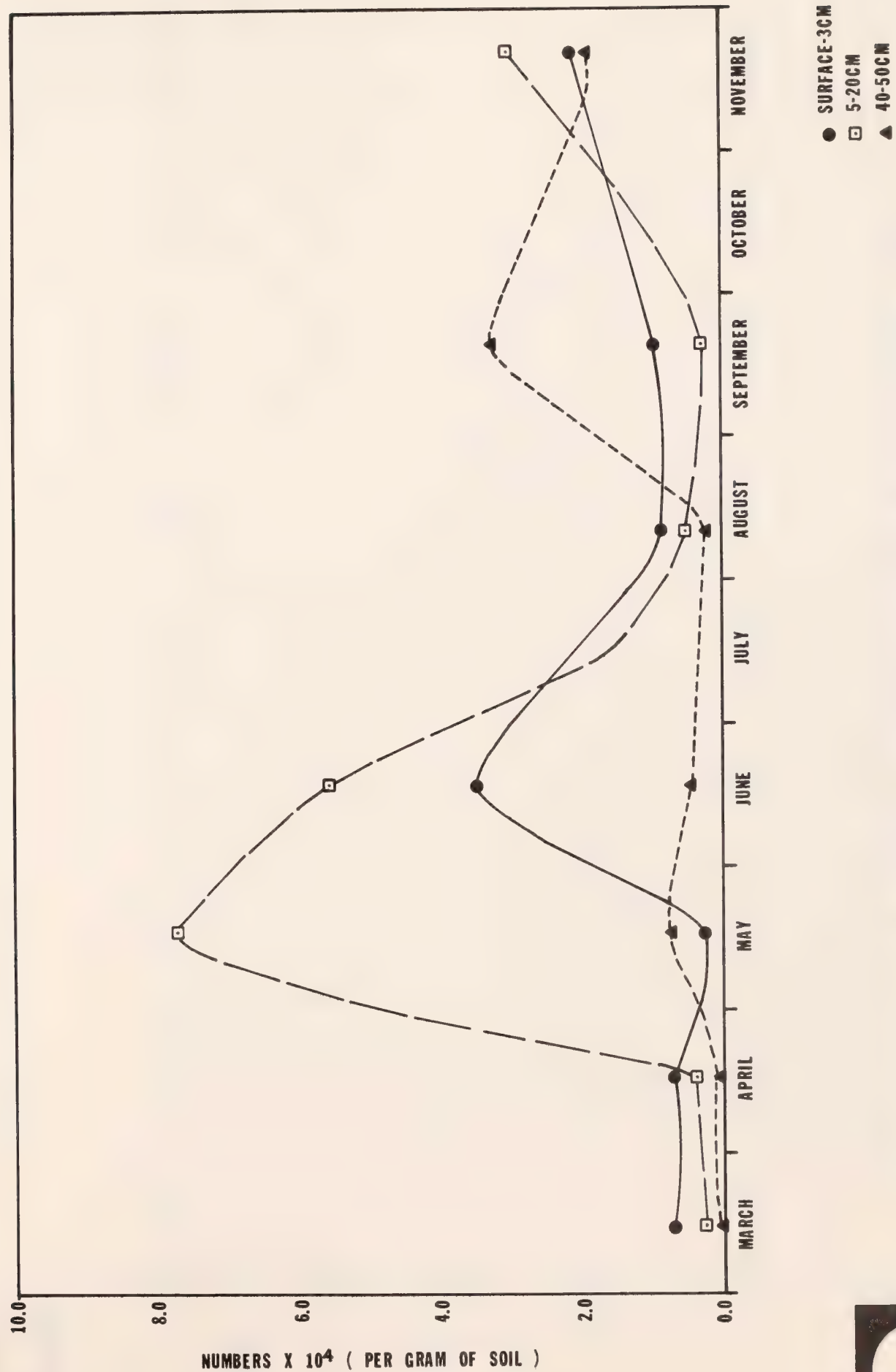
MEAN VALUES FOR ALL SITES OF NUMBERS OF ANAEROBIC BACTERIA FOR 1975 AND 1976 SAMPLES

● 1975
○ 1976



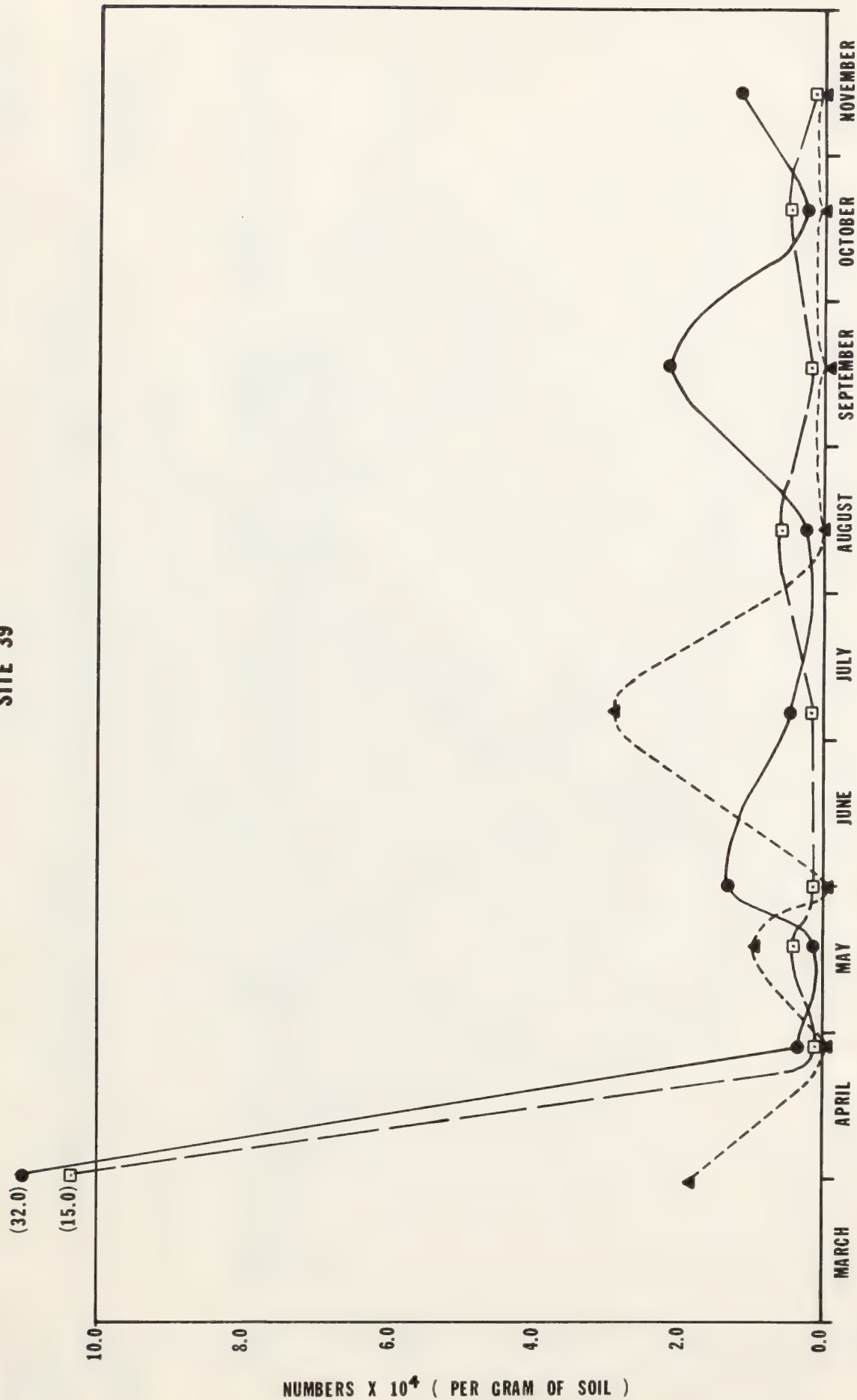
SURFACE





NUMBERS OF ANAEROBIC BACTERIA AT THREE DIFFERENT DEPTHS FOR 1976 SAMPLING DATES

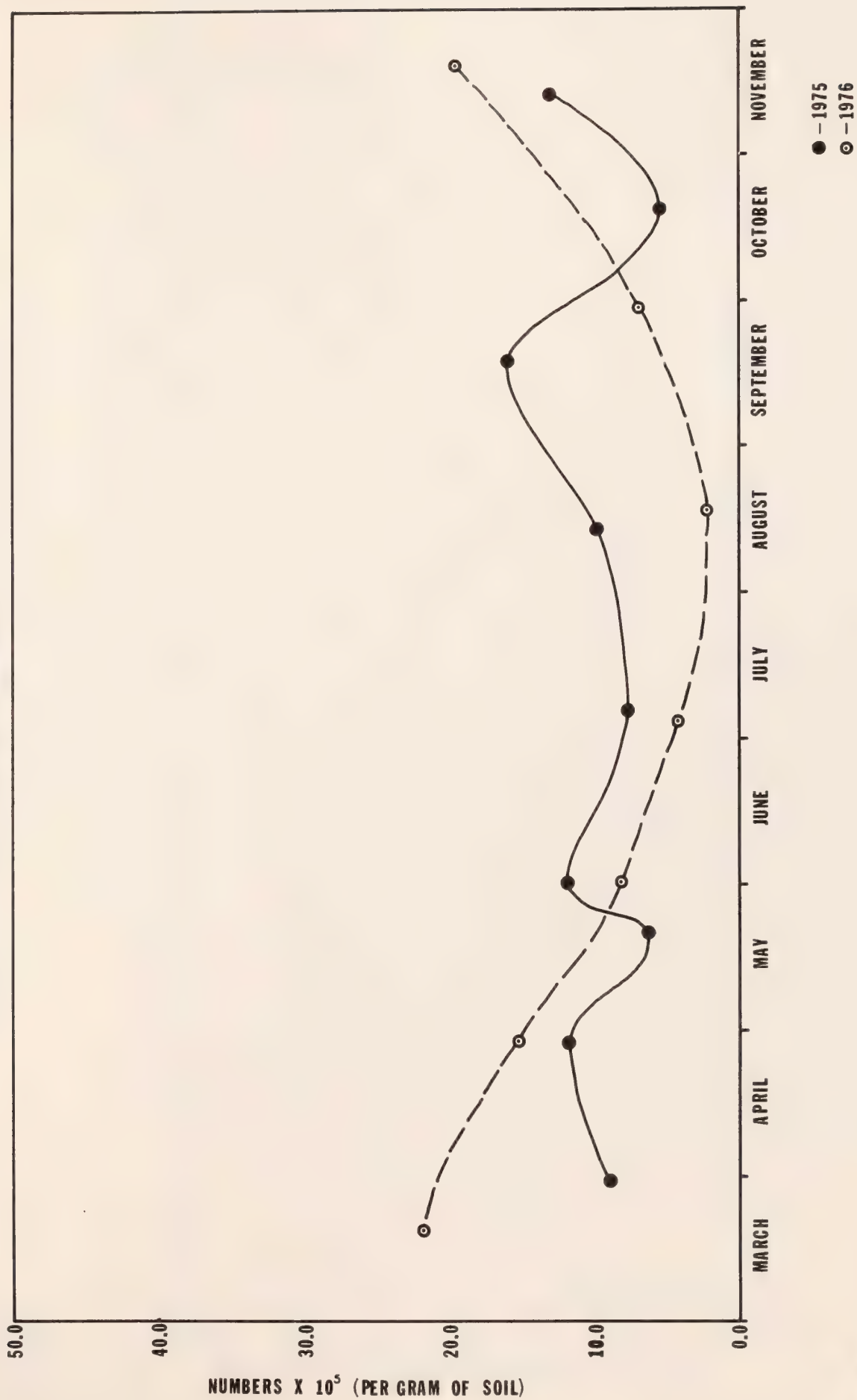




NUMBERS OF ANAEROBIC BACTERIA AT THREE DIFFERENT DEPTHS FOR 1975 SAMPLING DATES



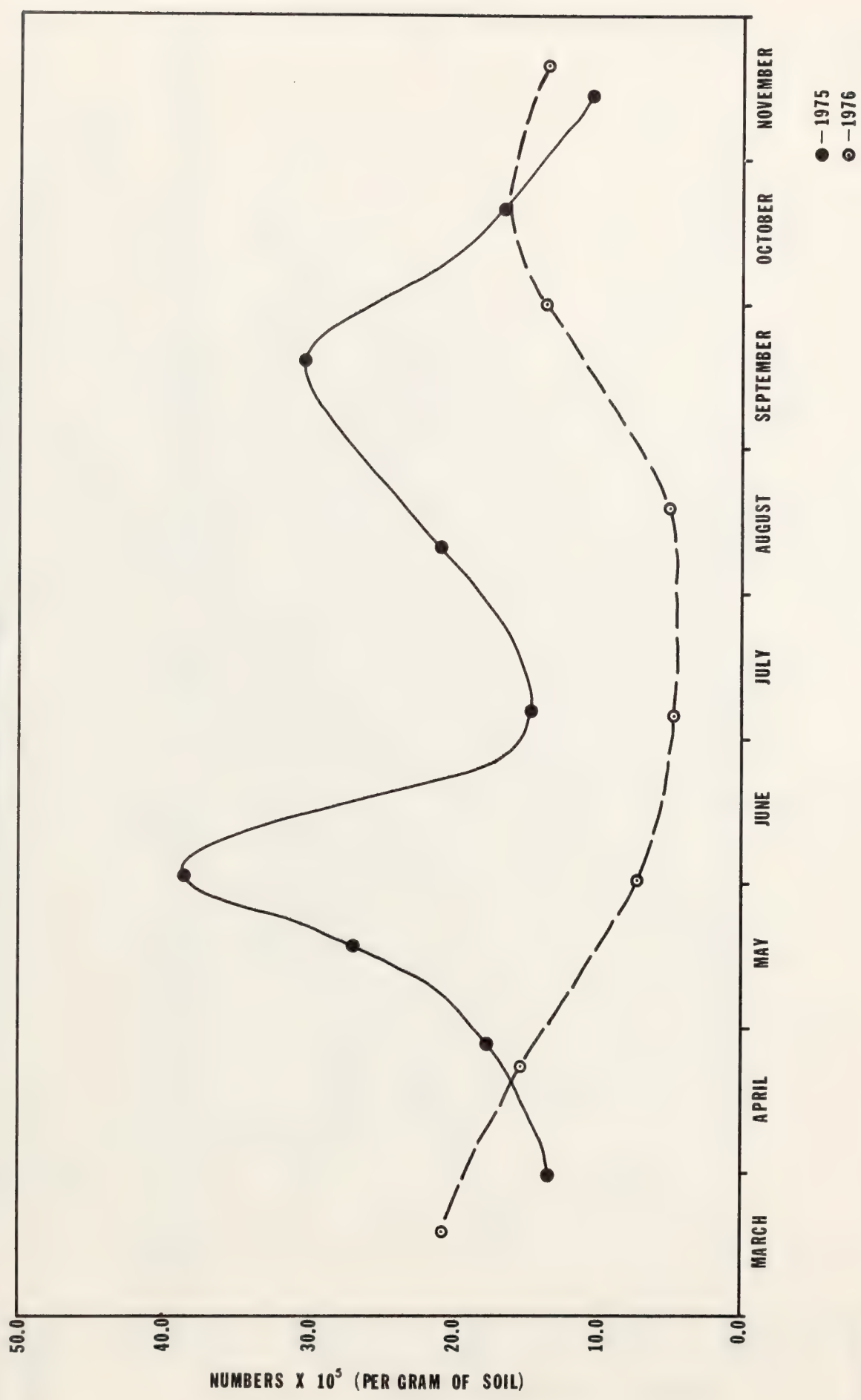
SITE 39 - SURFACE



NUMBERS OF STREPTOMYCETES FOR 1975 AND 1976 SAMPLING DATES



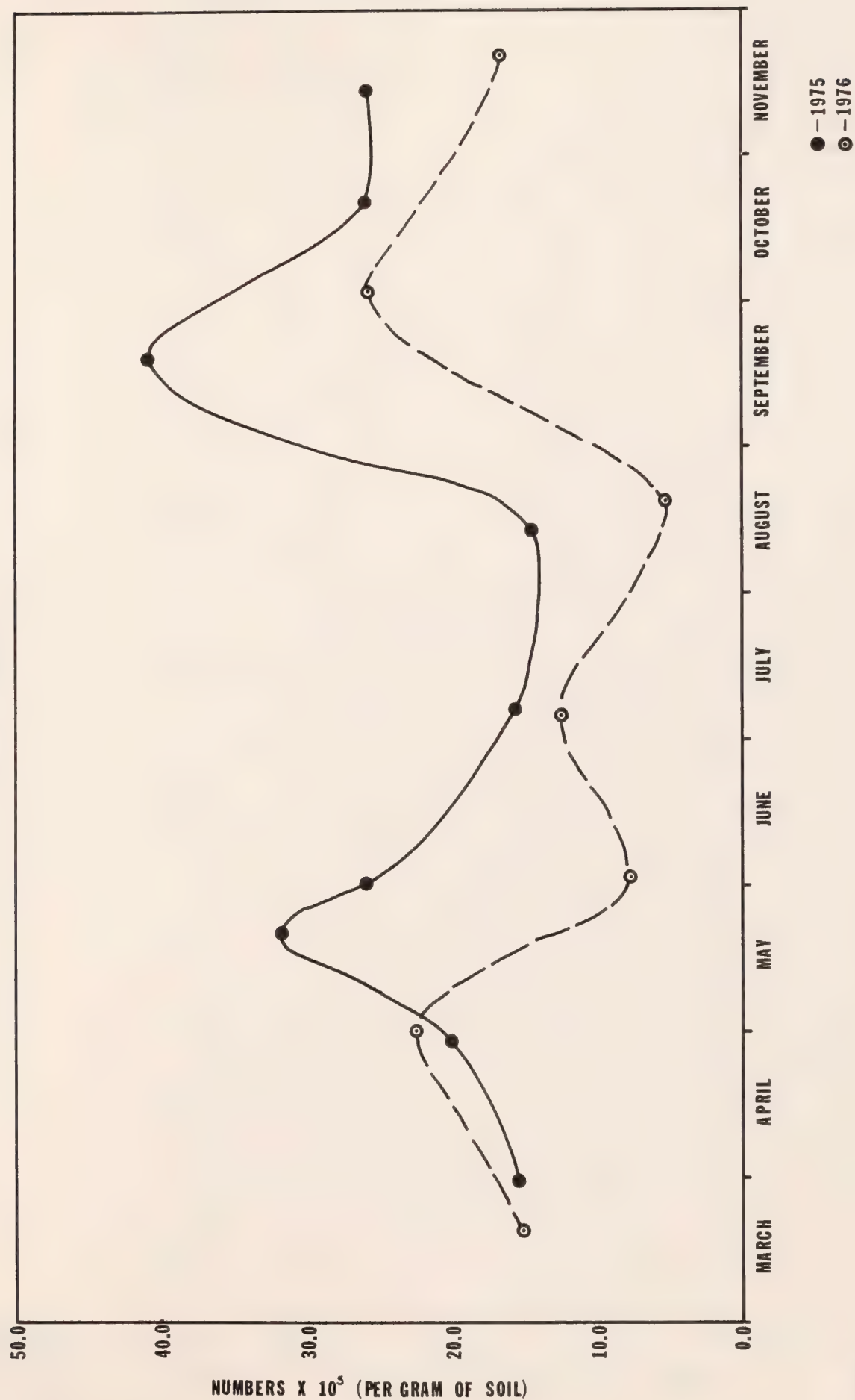
SITE 50JC - SURFACE



NUMBERS OF STREPTOMYCETES FOR 1975 AND 1976 SAMPLING DATES

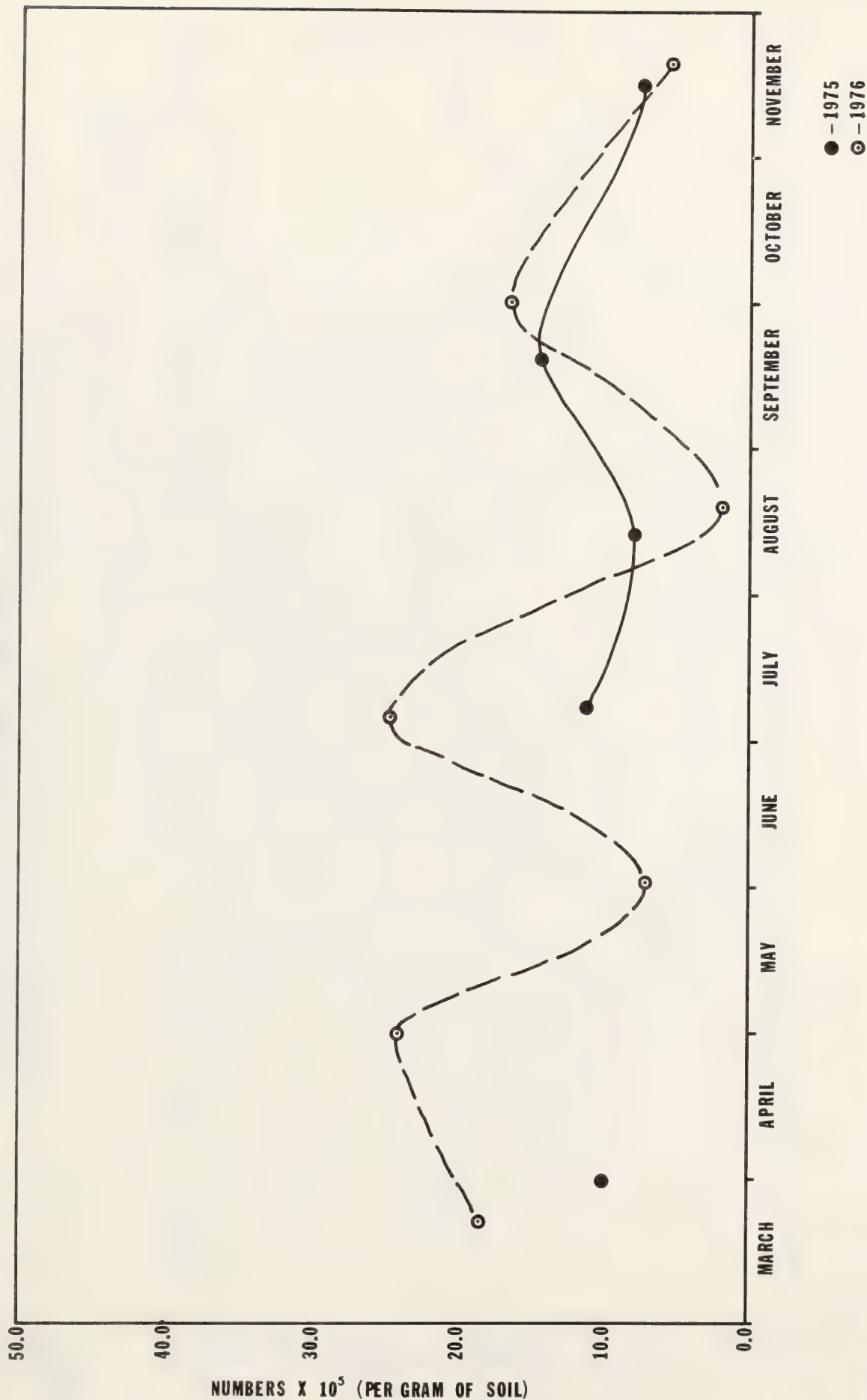


SITE 50JI - SURFACE



NUMBERS OF STREPTOMYCETES FOR 1975 AND 1976 SAMPLING DATES

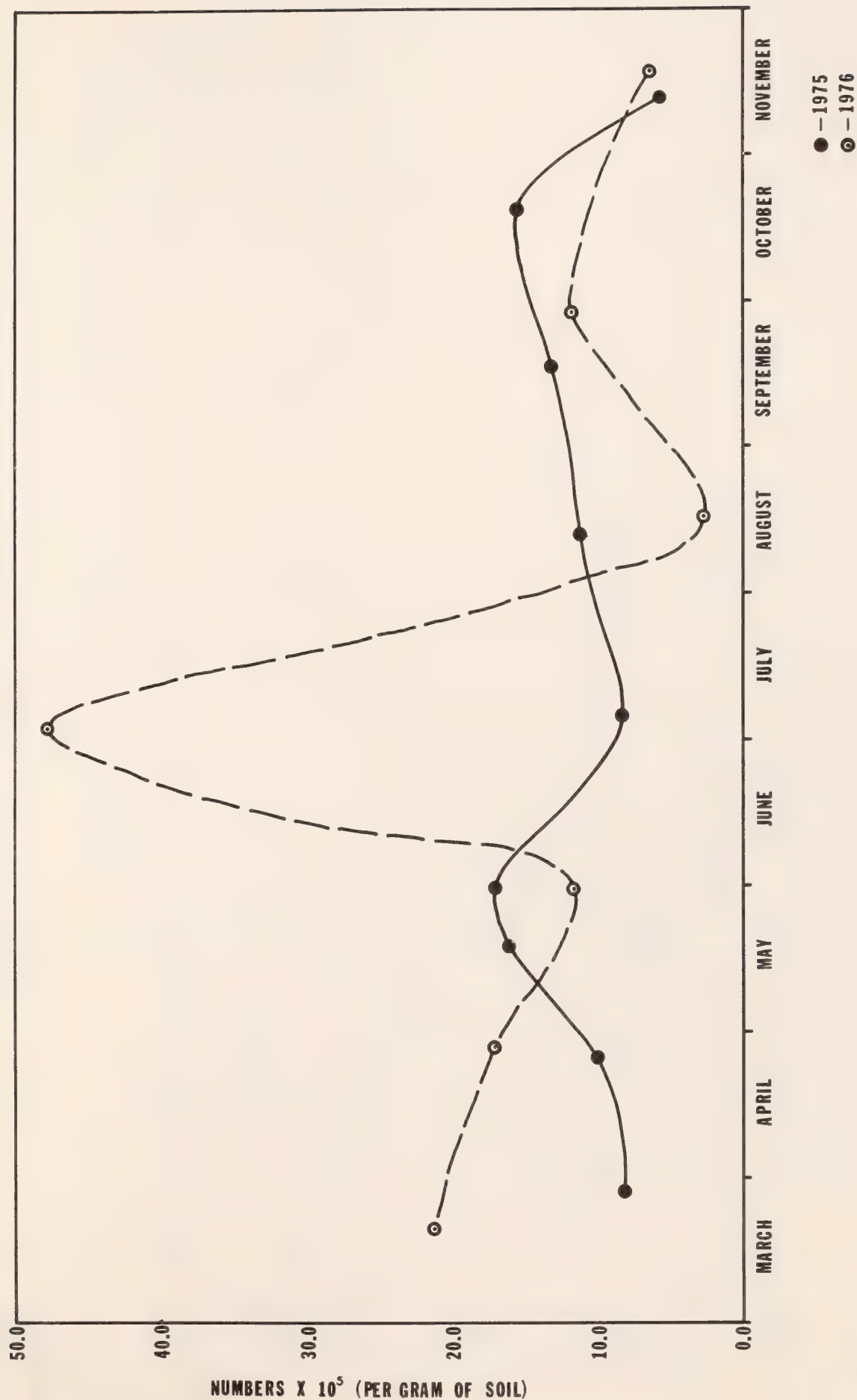


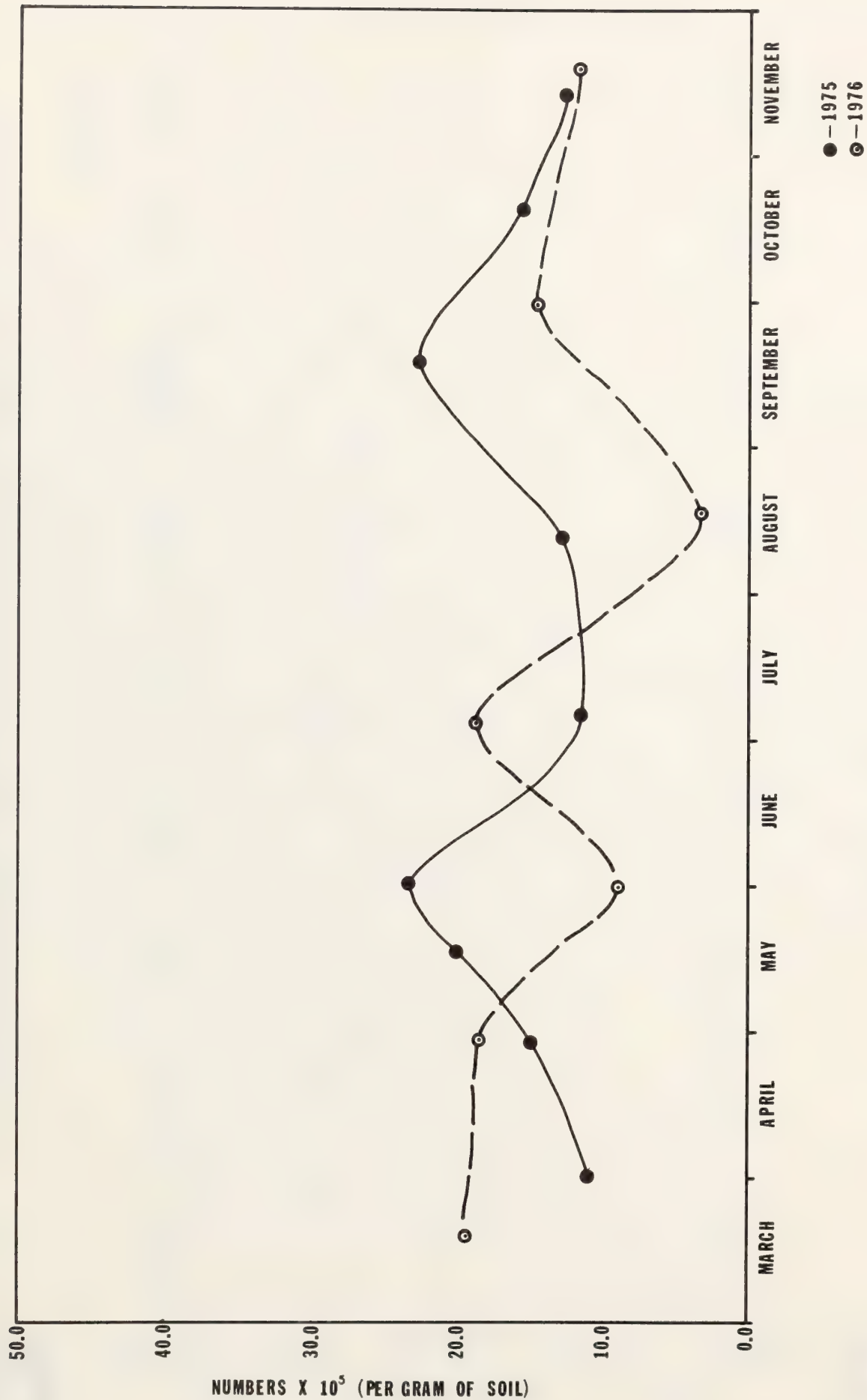


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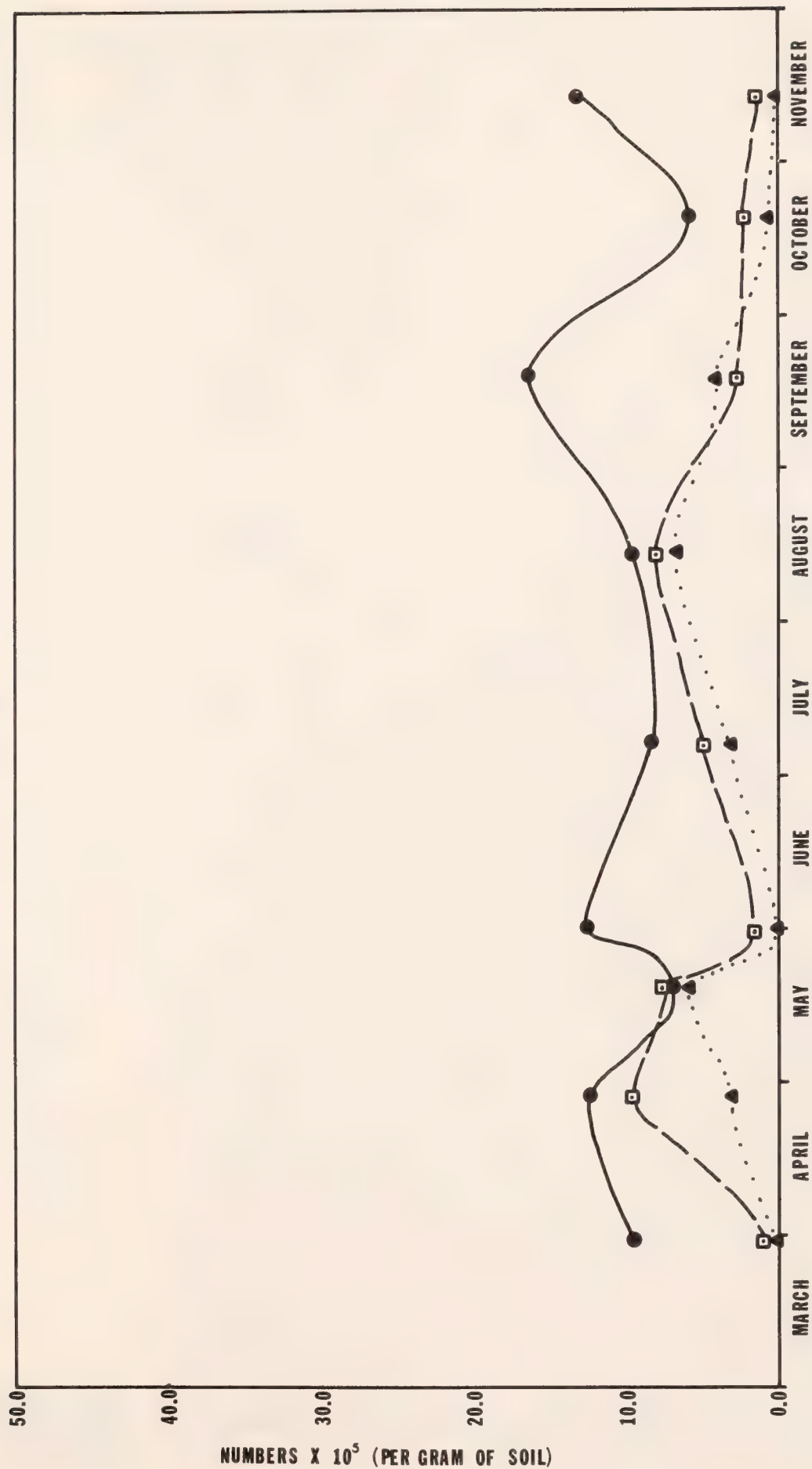
SITE 581 - SURFACE





MEAN VALUES FOR ALL SITES OF NUMBERS OF STREPTOMYCETES FOR 1975 AND 1976 SAMPLES

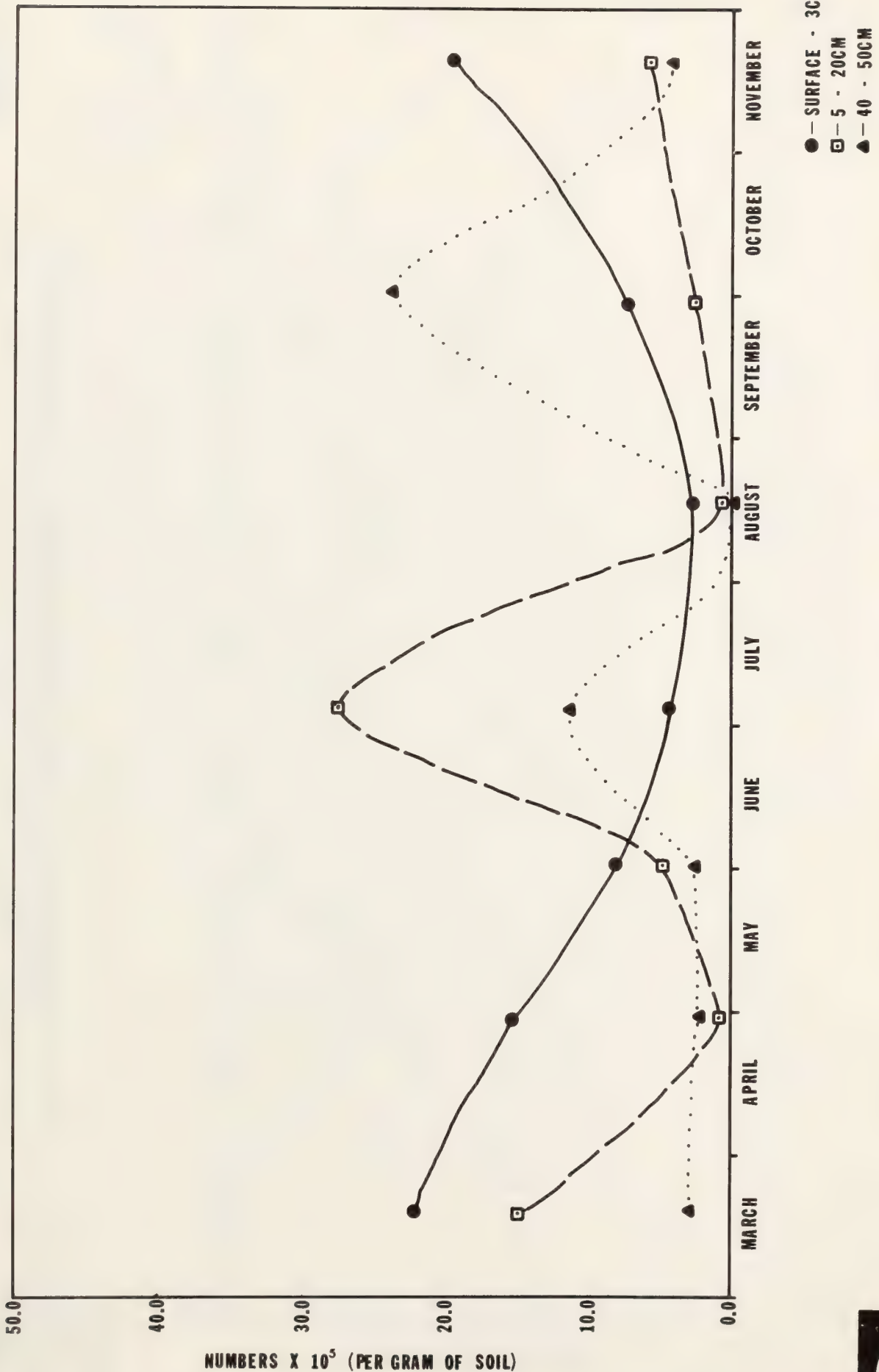




●—SURFACE - 3CM.
 □—5 - 20CM.
 ▲—40 - 50CM.

NUMBERS OF STREPTOMYCETES AT THREE DIFFERENT DEPTHS FOR 1975 SAMPLING DATES

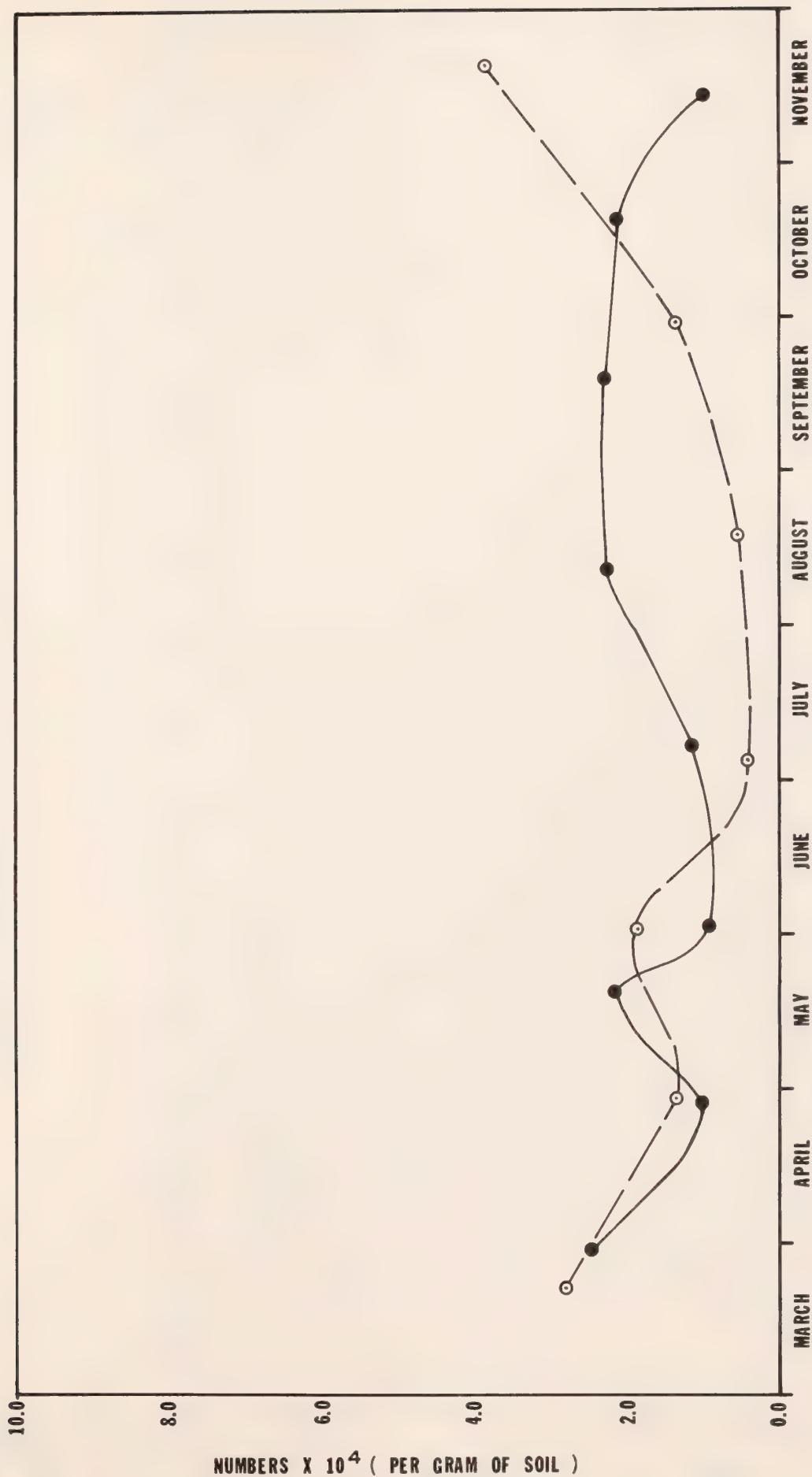




NUMBERS X 10⁵ (PER GRAM OF SOIL)

NUMBERS OF STREPTOMYCETES AT THREE DIFFERENT DEPTHS FOR 1976 SAMPLING DATES





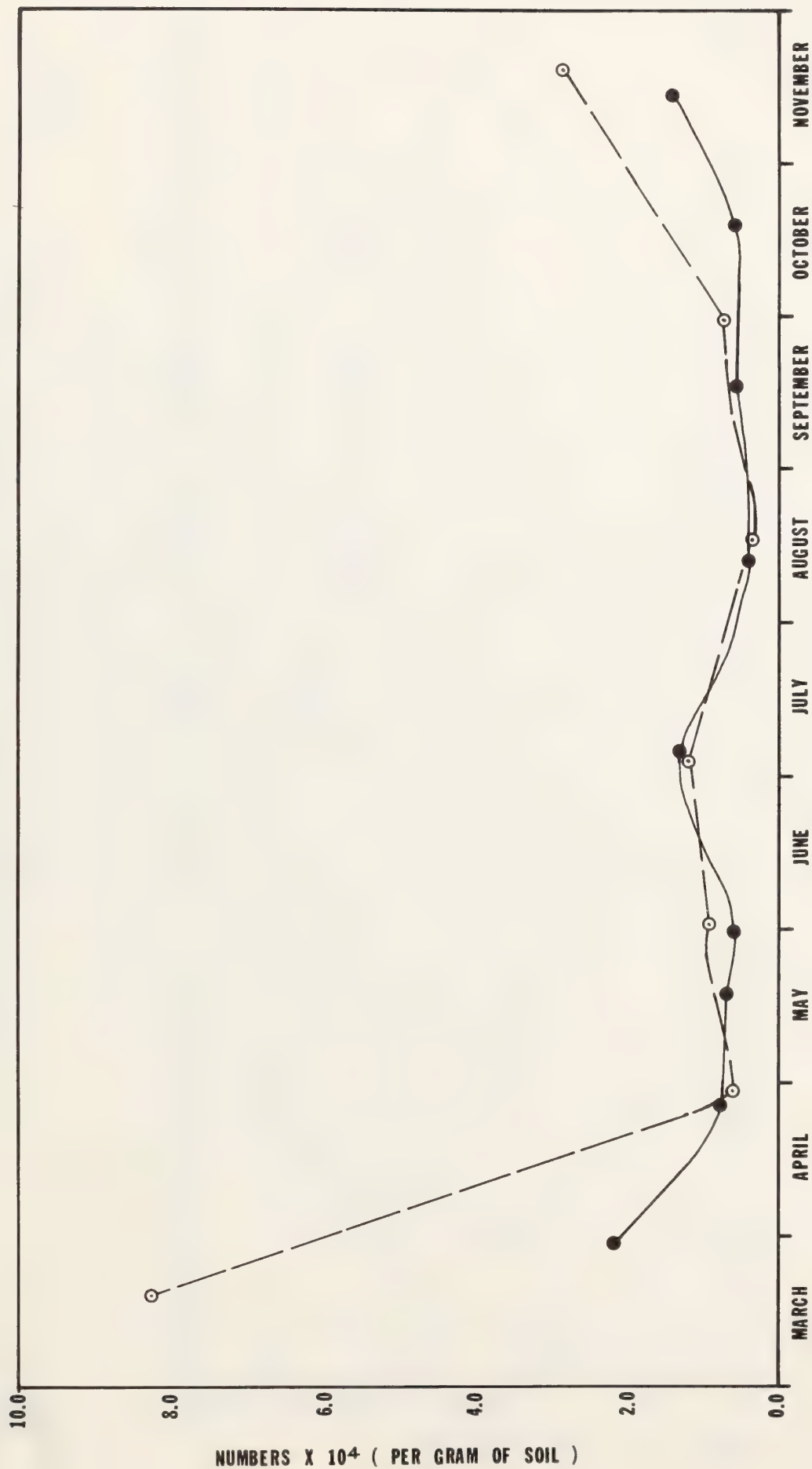
● 1975
○ 1976

NUMBERS OF FUNGI FOR 1975 AND 1976 SAMPLING DATES

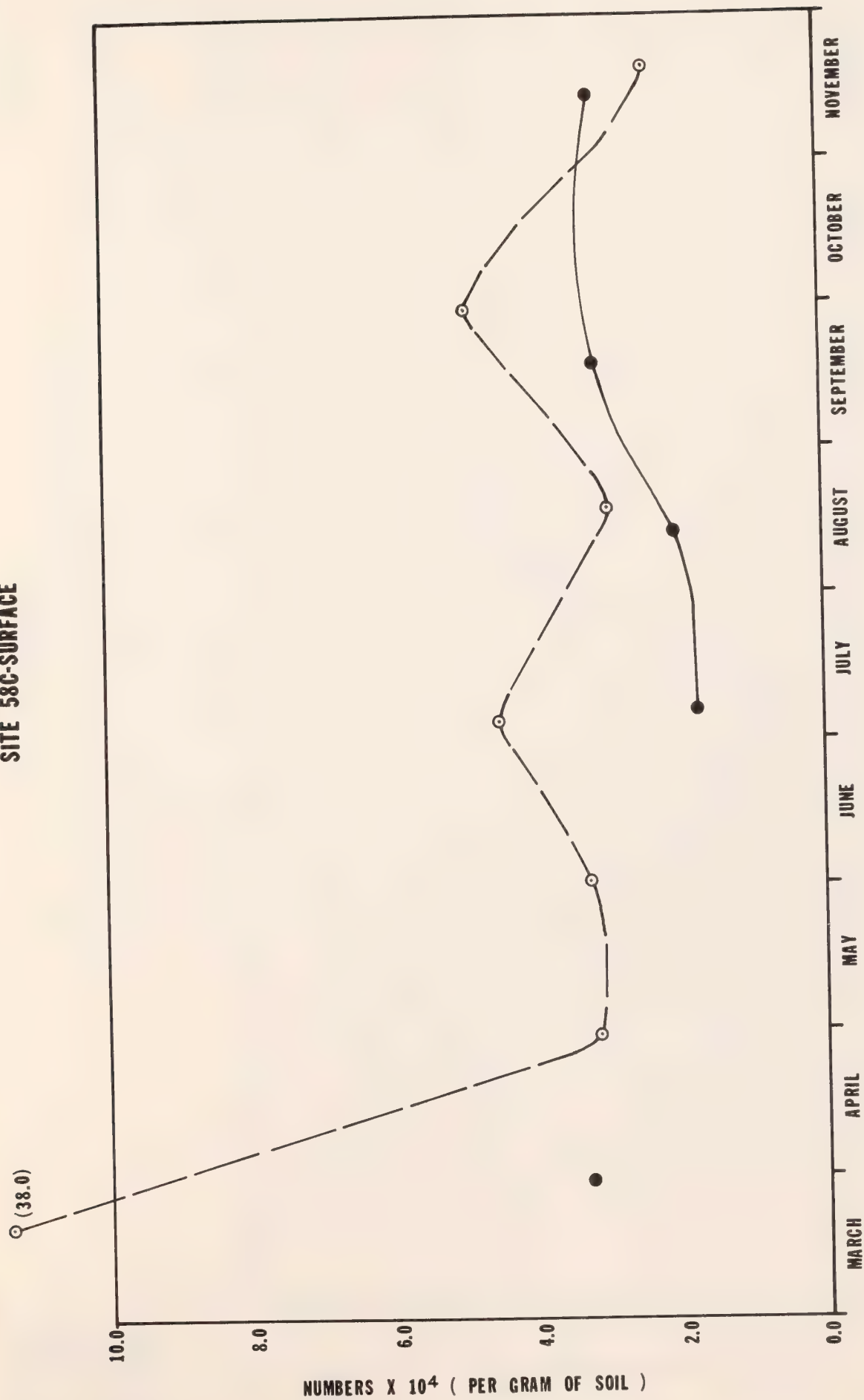


NUMBERS OF FUNGI FOR 1975 AND 1976 SAMPLING DATES

● 1975
○ 1976

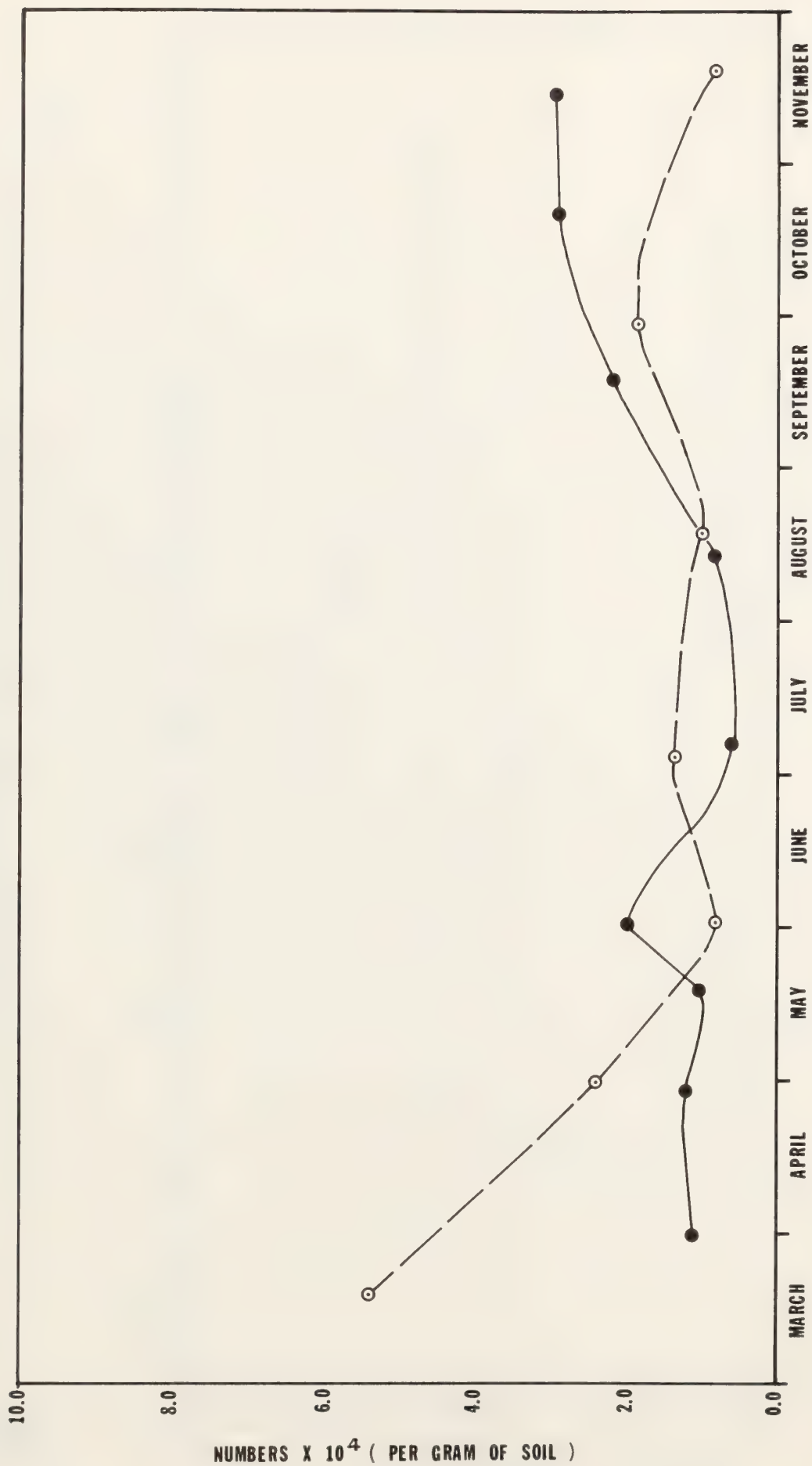


SITE 58C-SURFACE



NUMBERS OF FUNGI FOR 1975 AND 1976 SAMPLING DATES



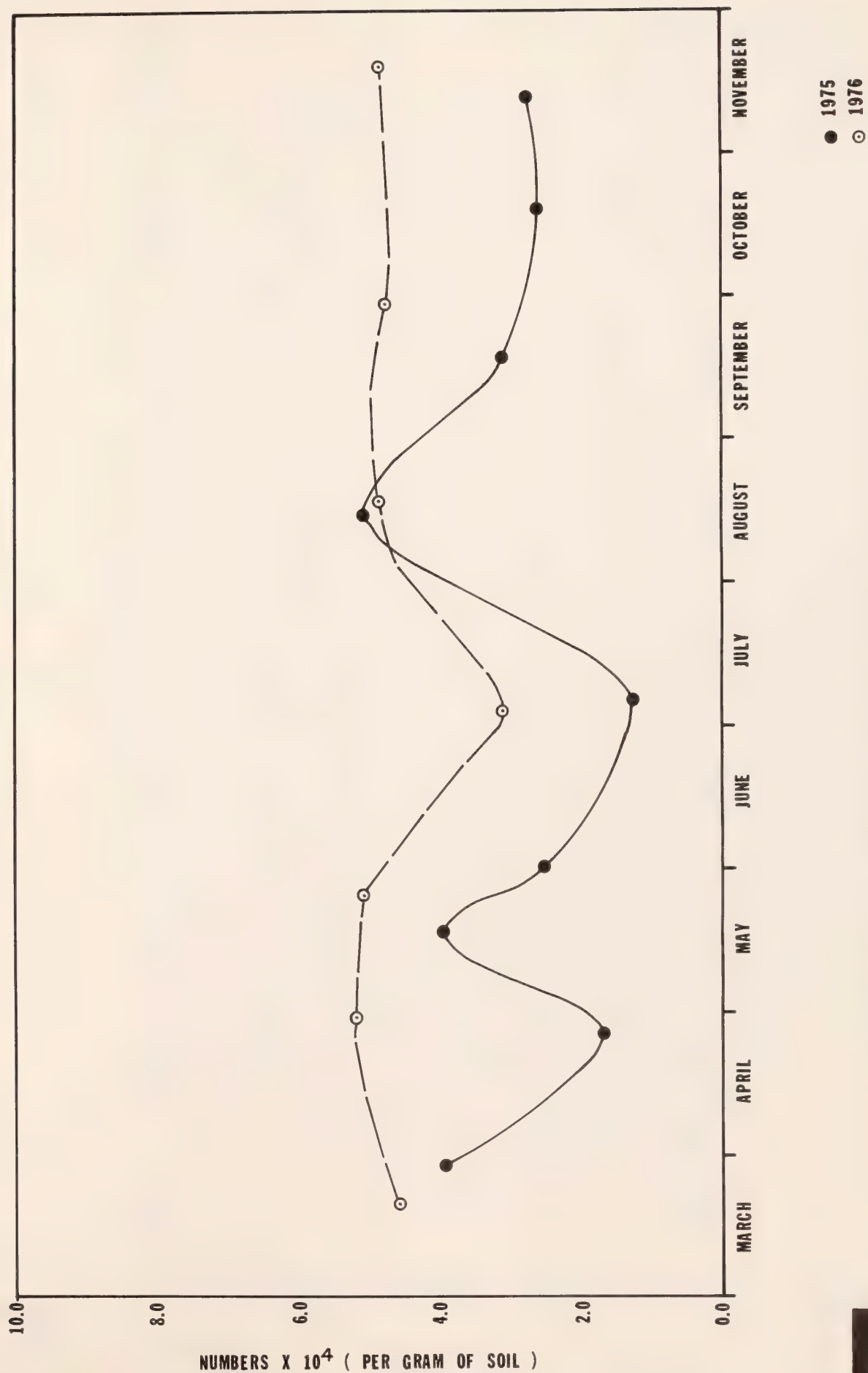


● 1975
○ 1976

NUMBERS OF FUNGI FOR 1975 AND 1976 SAMPLING DATES



SITE 50JC-SURFACE

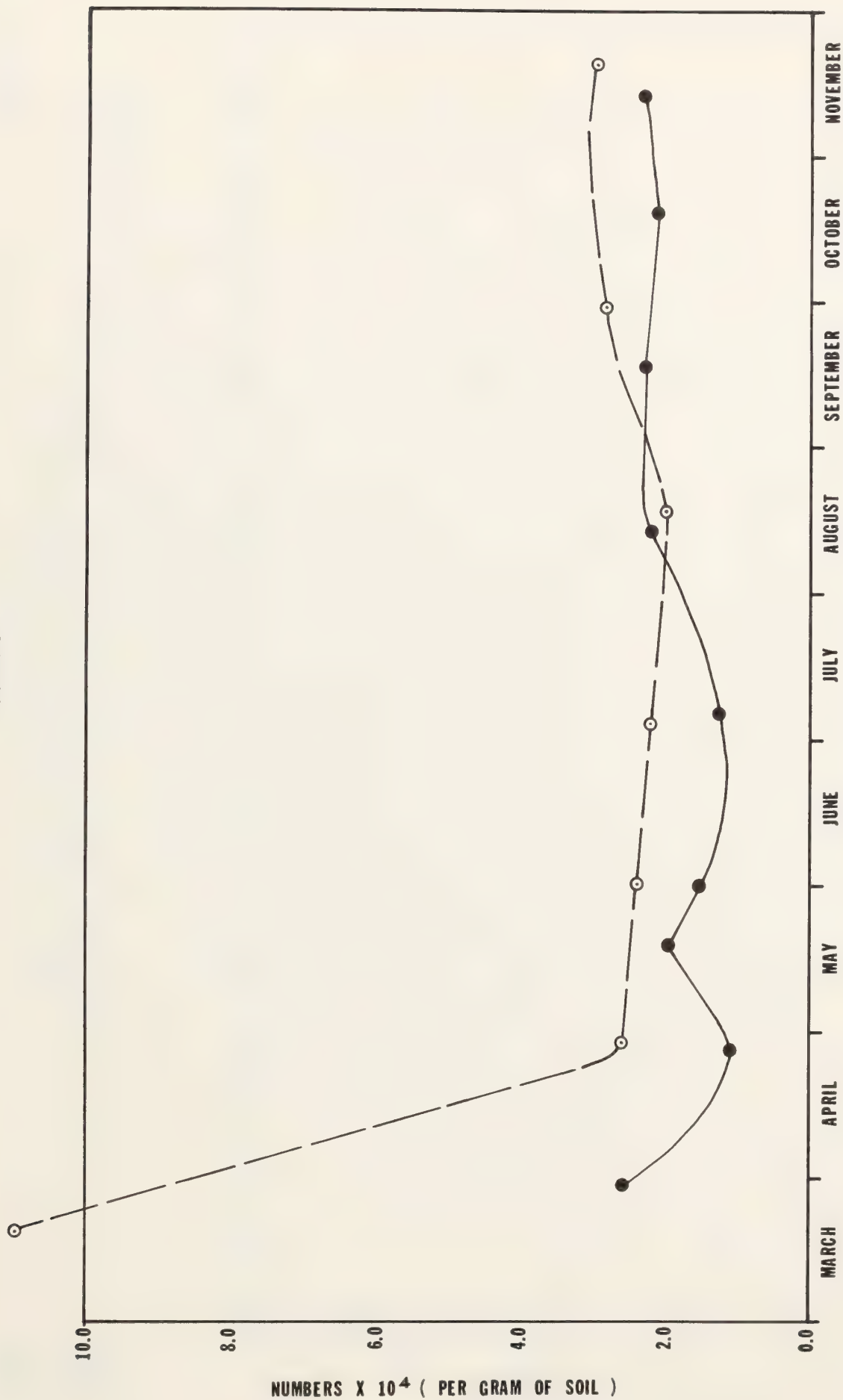


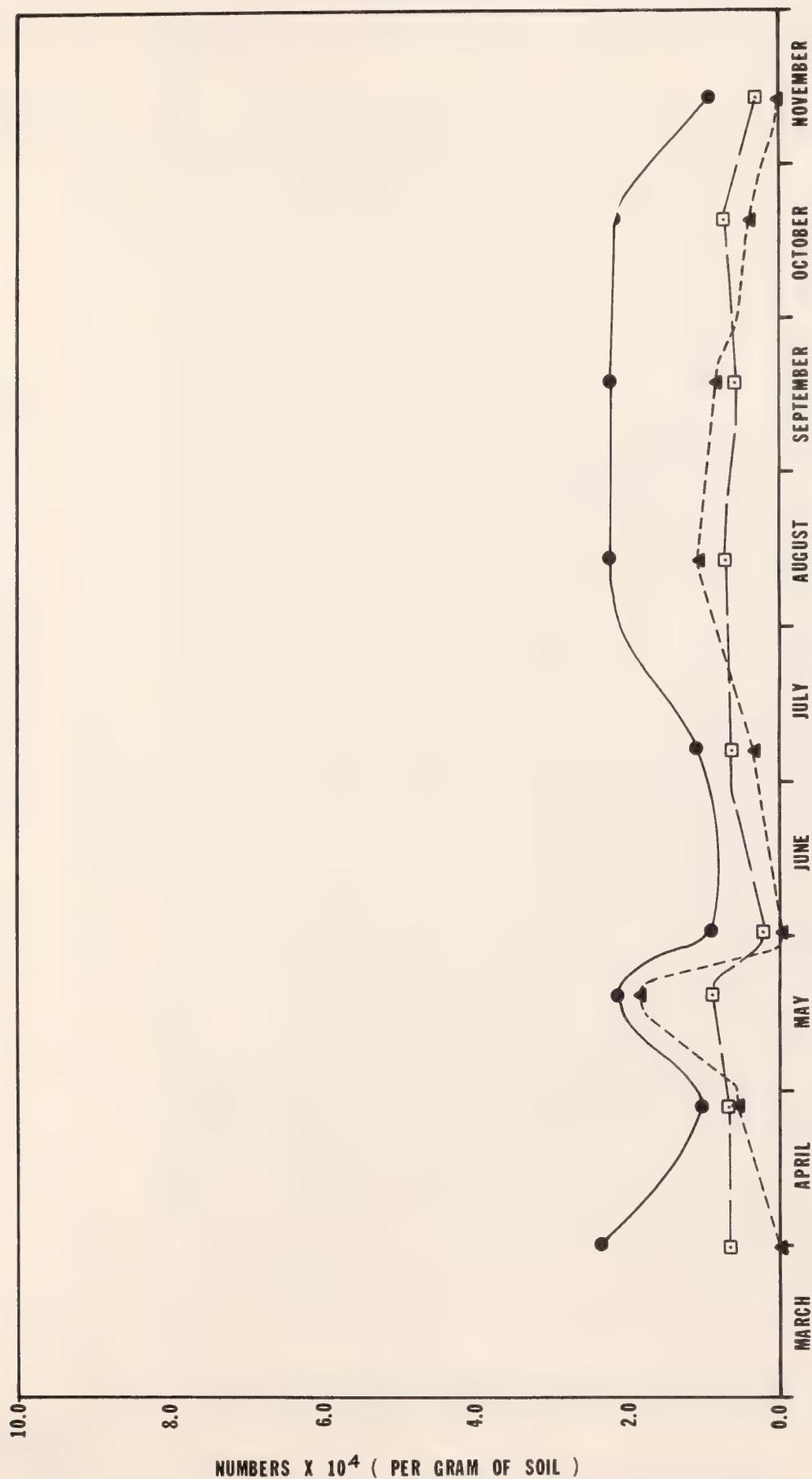
NUMBERS OF FUNGI FOR 1975 AND 1976 SAMPLING DATES



MEAN VALUES FOR ALL SITES OF NUMBERS OF FUNGI FOR 1975 AND 1976 SAMPLES

● 1975
○ 1976

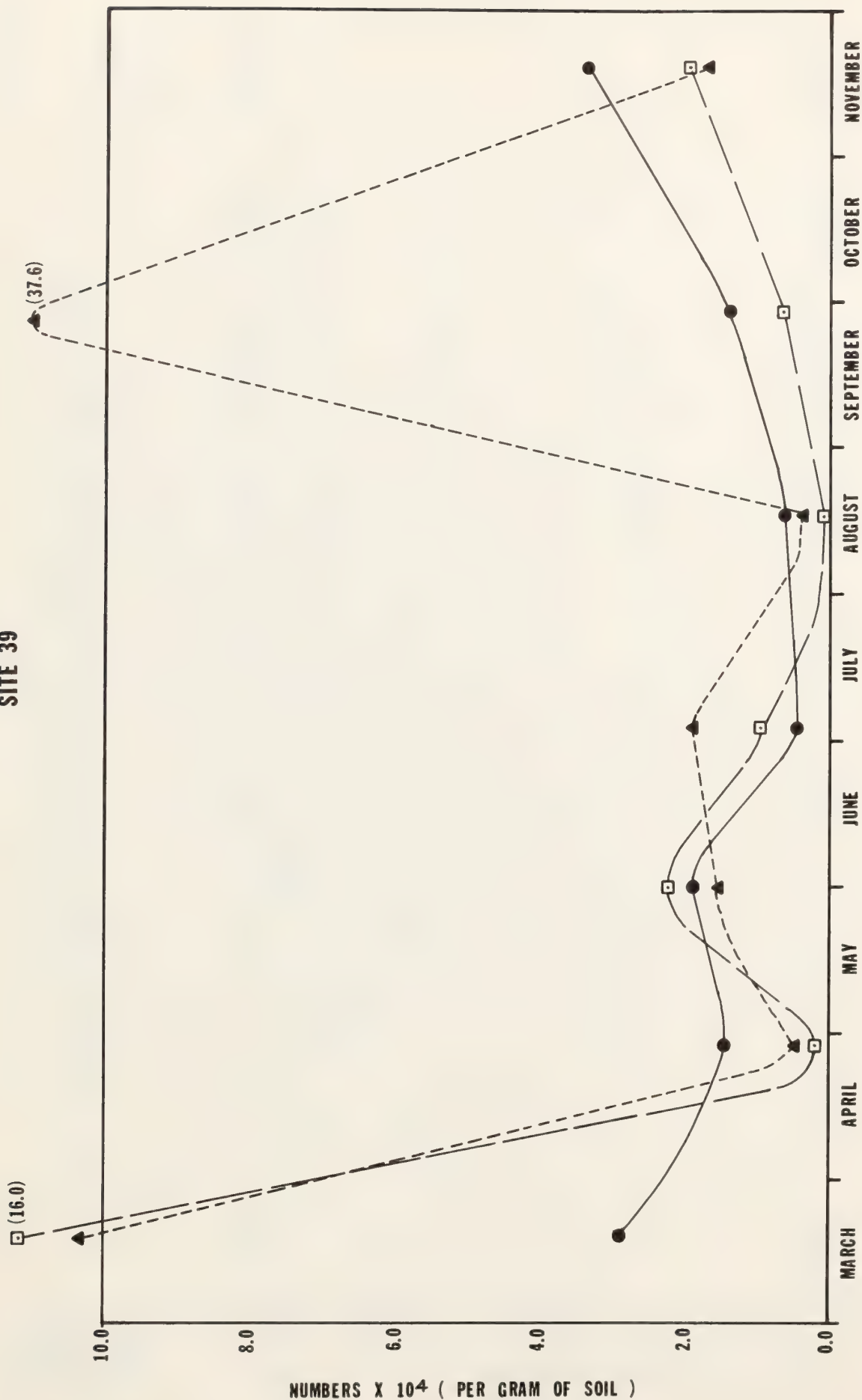




NUMBERS OF FUNGI AT THREE DIFFERENT DEPTHS FOR 1975 SAMPLING DATES



SITE 39

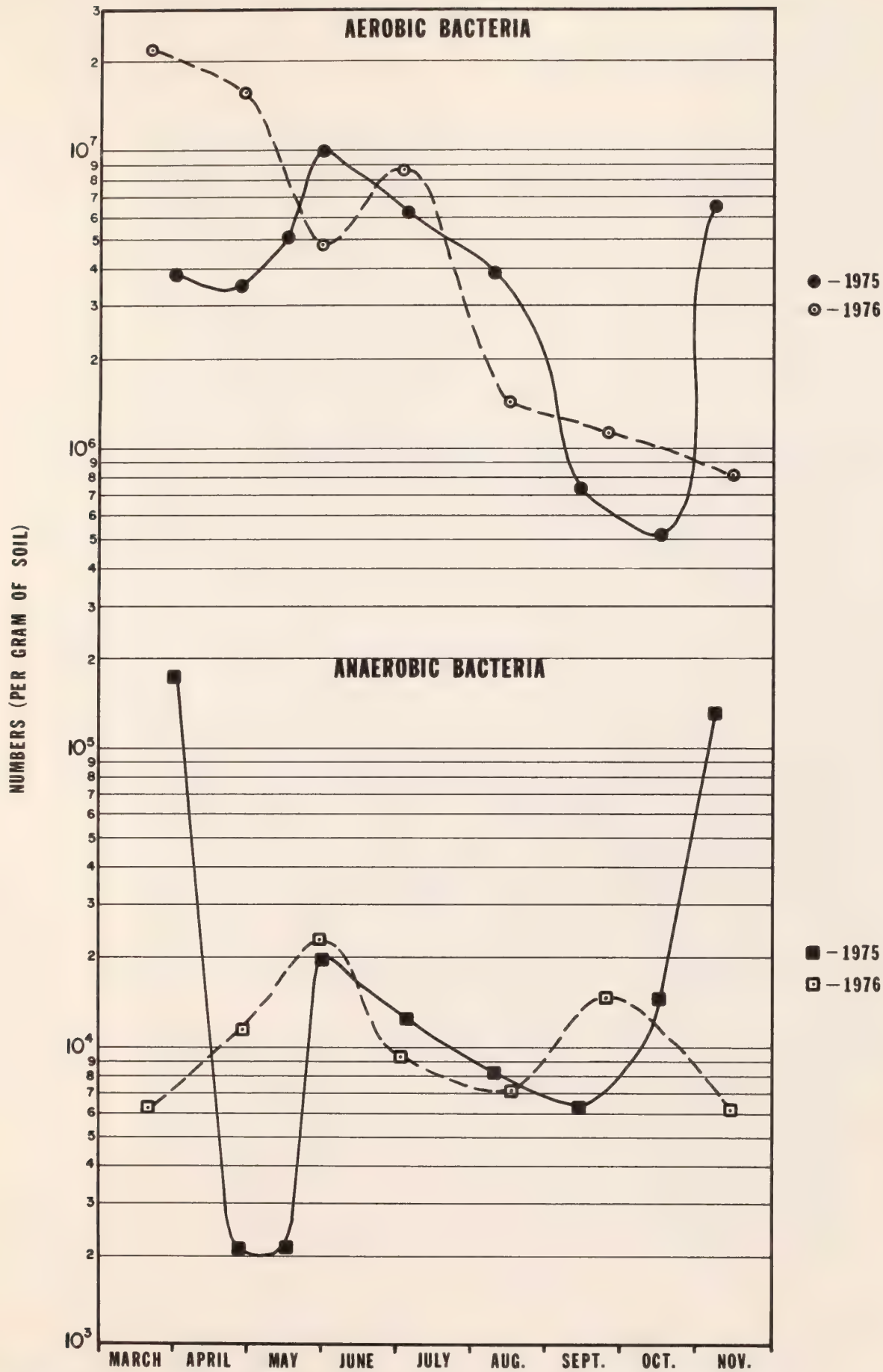


● SURFACE-3CM
□ 5-20CM
▲ 40-50CM

NUMBERS OF FUNGI AT THREE DIFFERENT DEPTHS FOR 1976 SAMPLING DATES

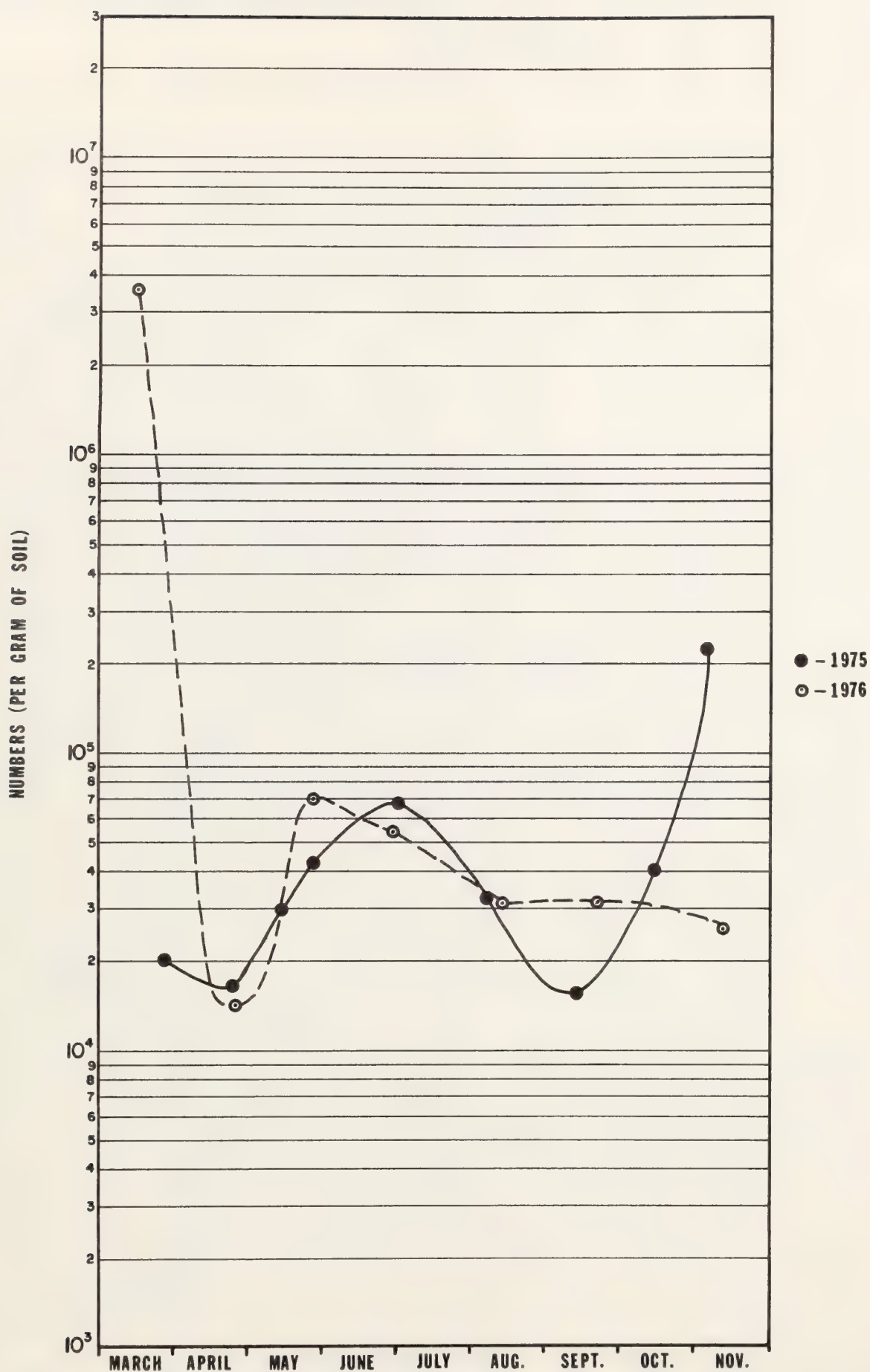
APPENDIX IV-42





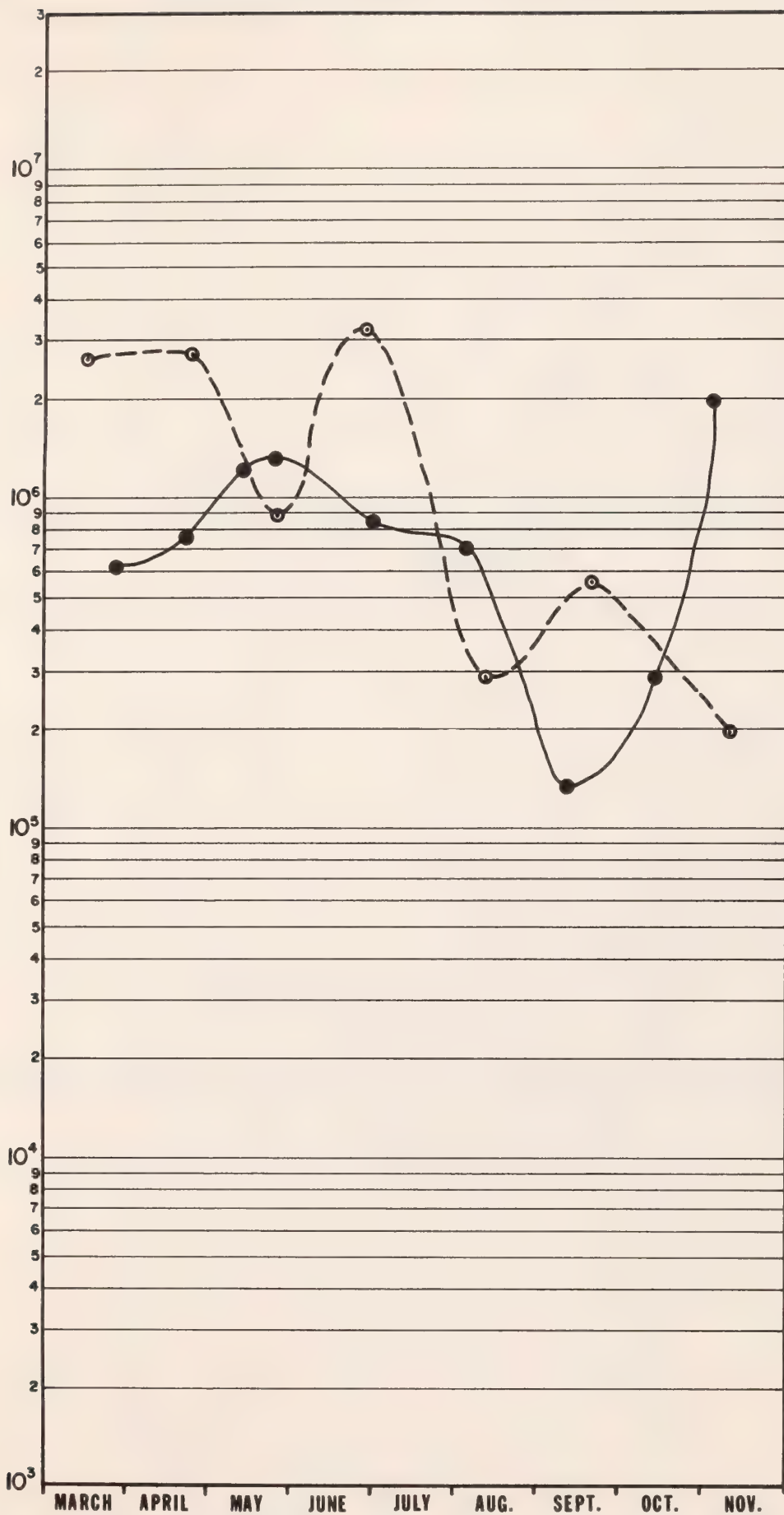
NUMBERS OF AEROBIC AND ANAEROBIC BACTERIA OF SITE 55R





NUMBERS OF FUNGI IN THE SURFACE SOIL OF SITE 55R

NUMBERS (PER GRAM OF SOIL)

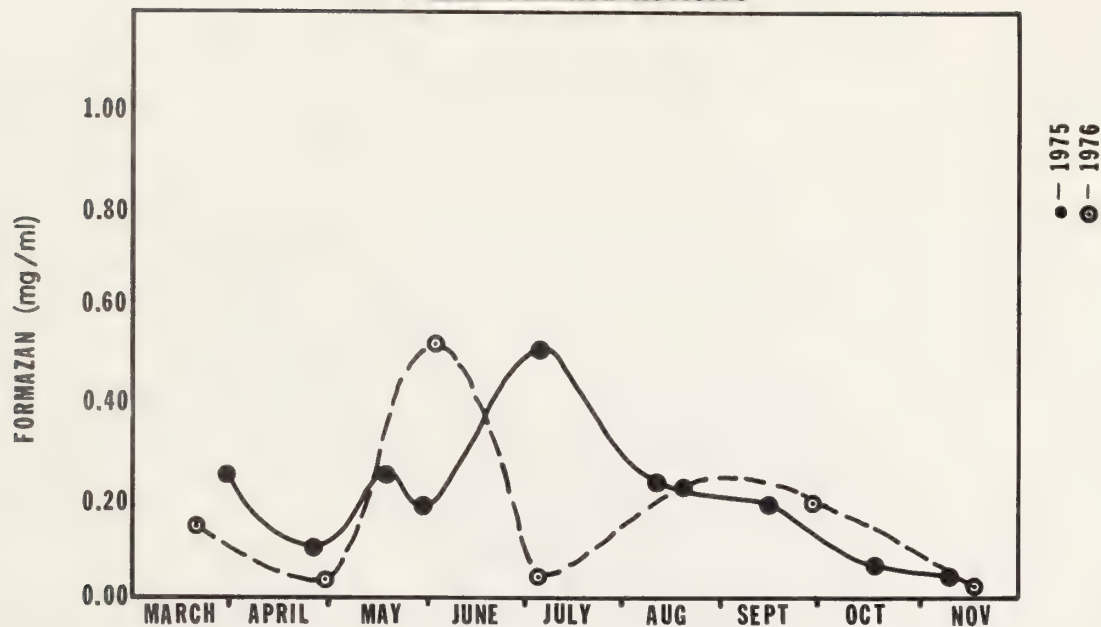


● - 1975
○ - 1976

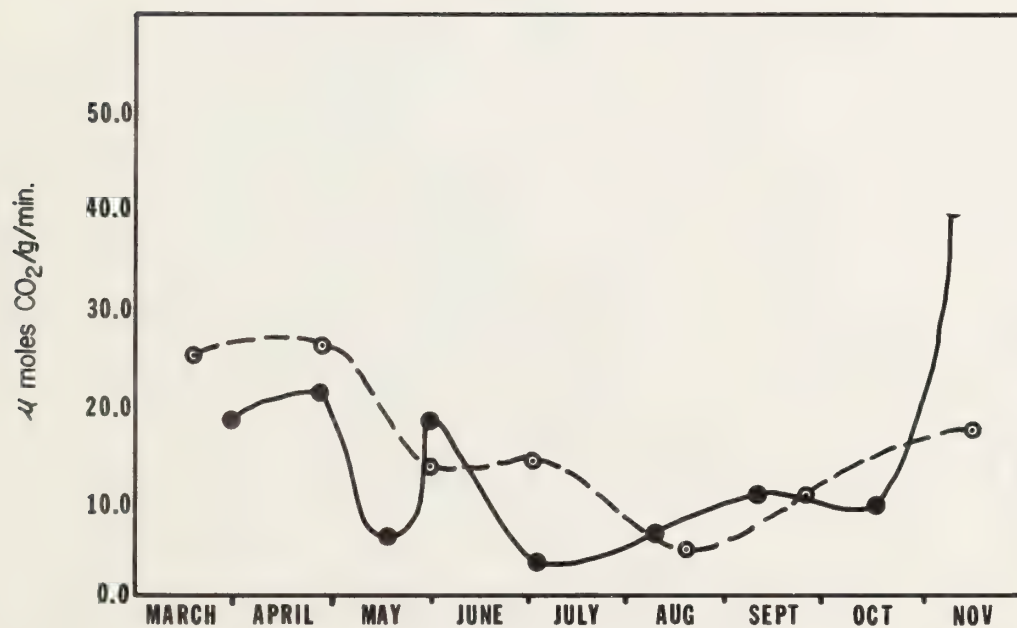


NUMBERS OF STREPTOMYCETE IN THE SURFACE SOIL OF SITE 55R

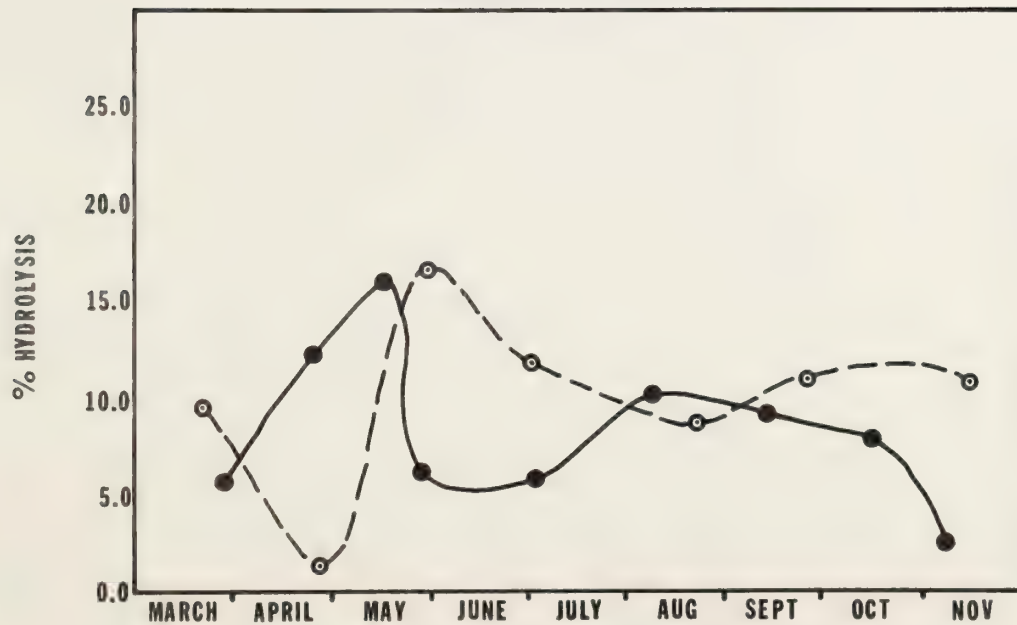
DEHYDROGENASE ACTIVITY



RESPIRATION



PROTEOLYTIC ACTIVITY

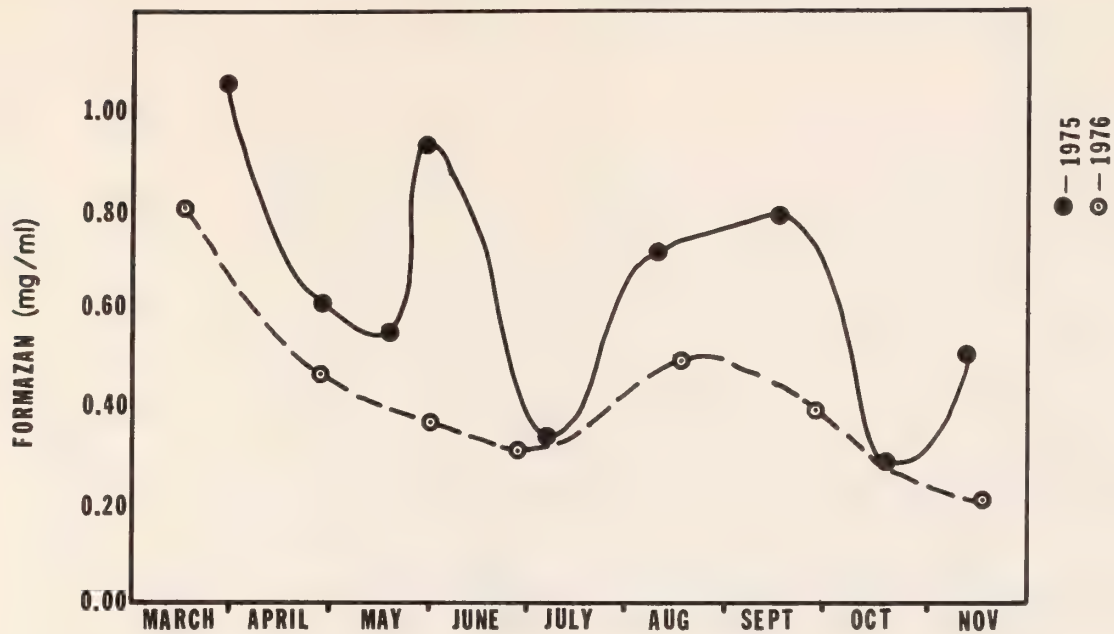


MICROBIAL ACTIVITIES IN SITE 39 SURFACE SOIL FOR 1975 AND 1976 SAMPLING DATES

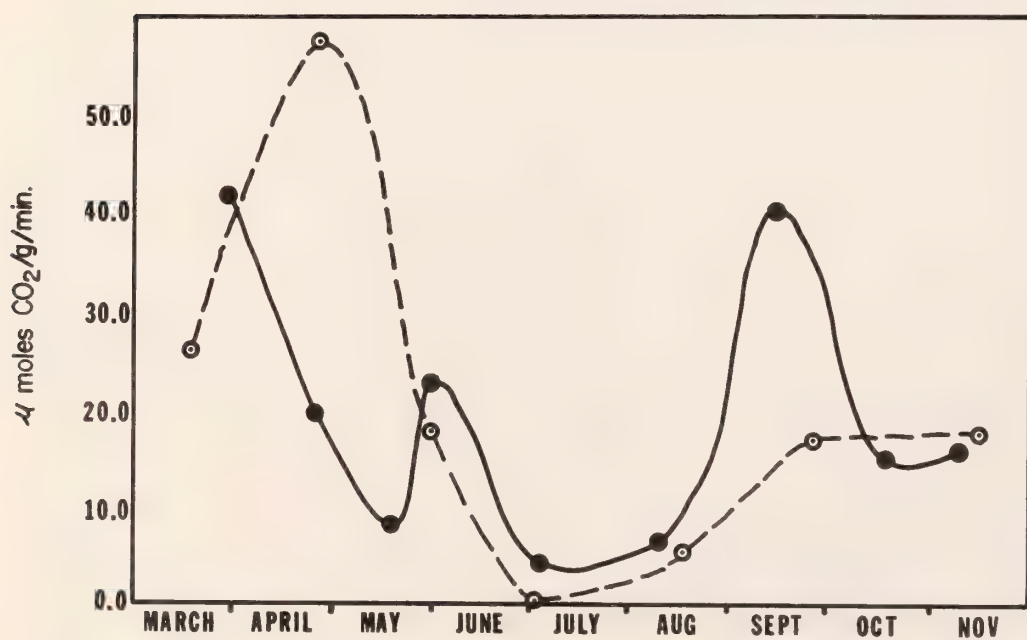
APPENDIX IV-46



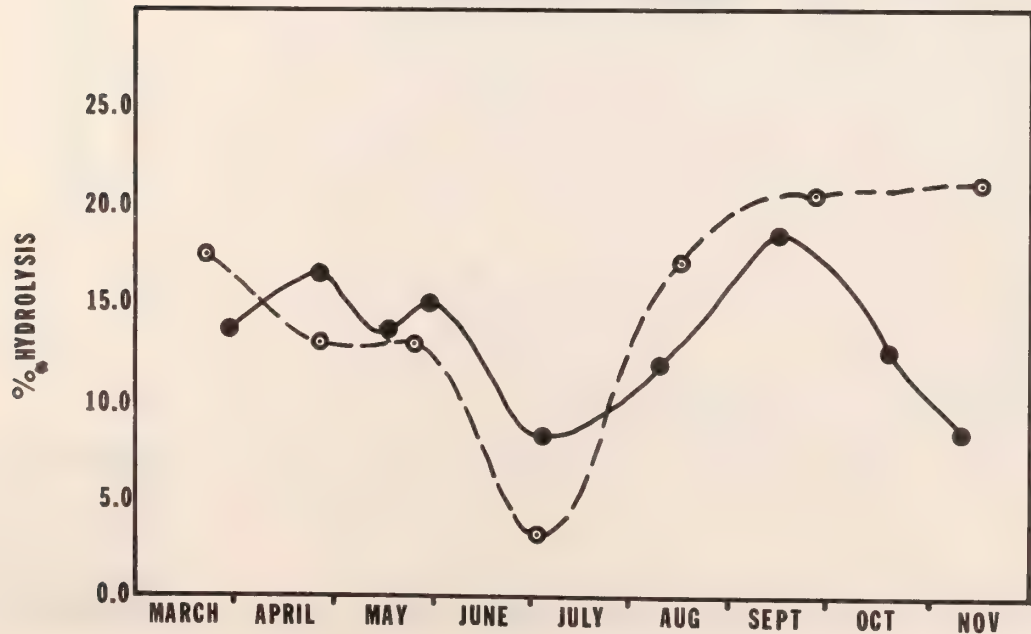
DEHYDROGENASE ACTIVITY



RESPIRATION



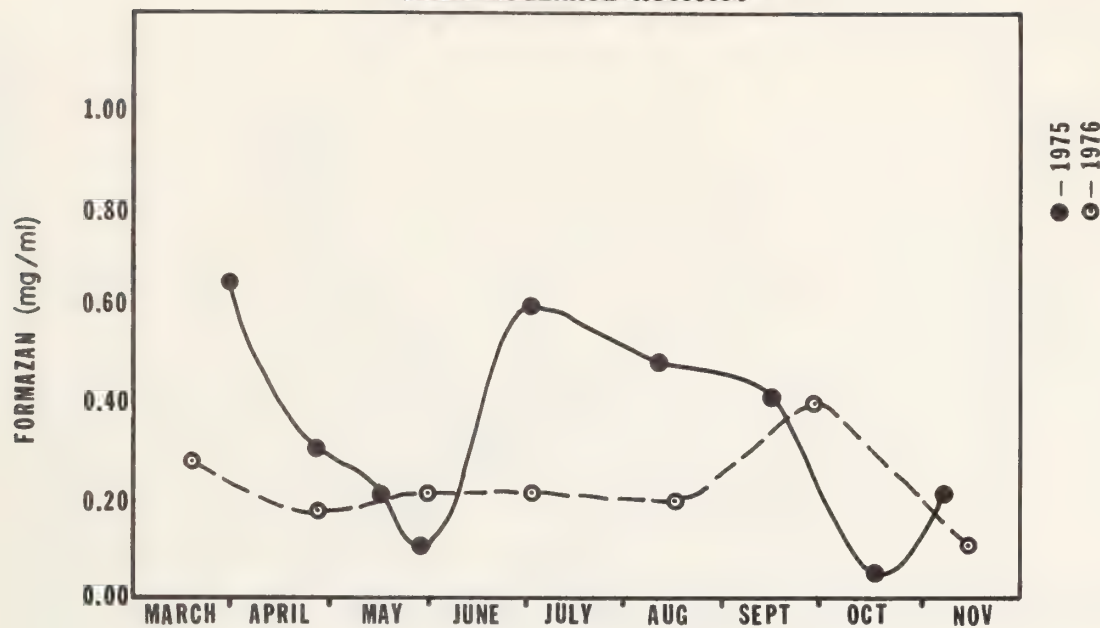
PROTEOLYTIC ACTIVITY



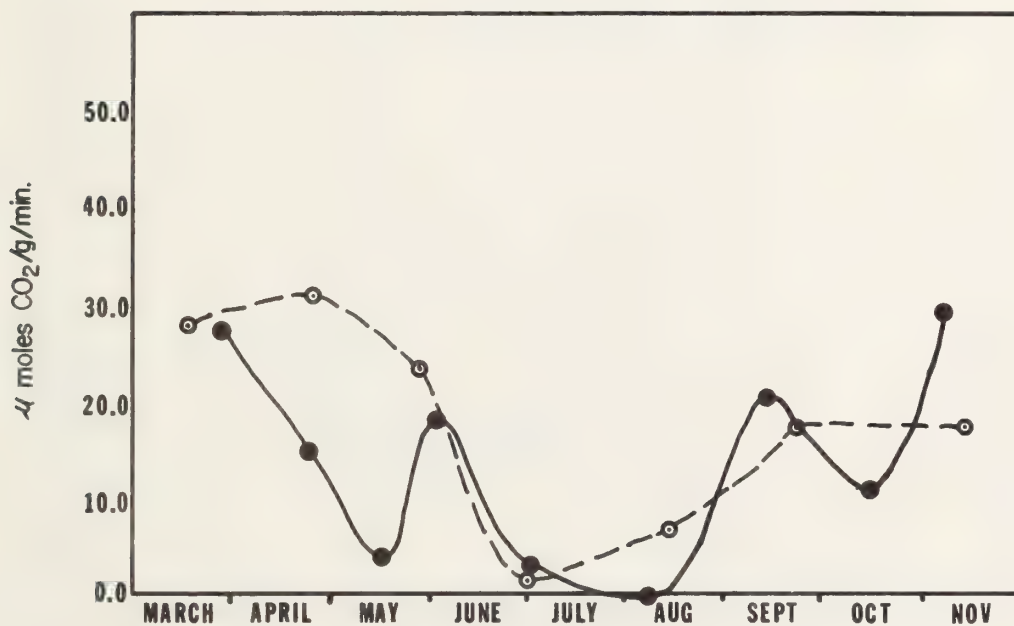
MICROBIAL ACTIVITIES IN SITE 50JC SURFACE SOIL FOR 1975 AND 1976 SAMPLING DATES

APPENDIX IV-47

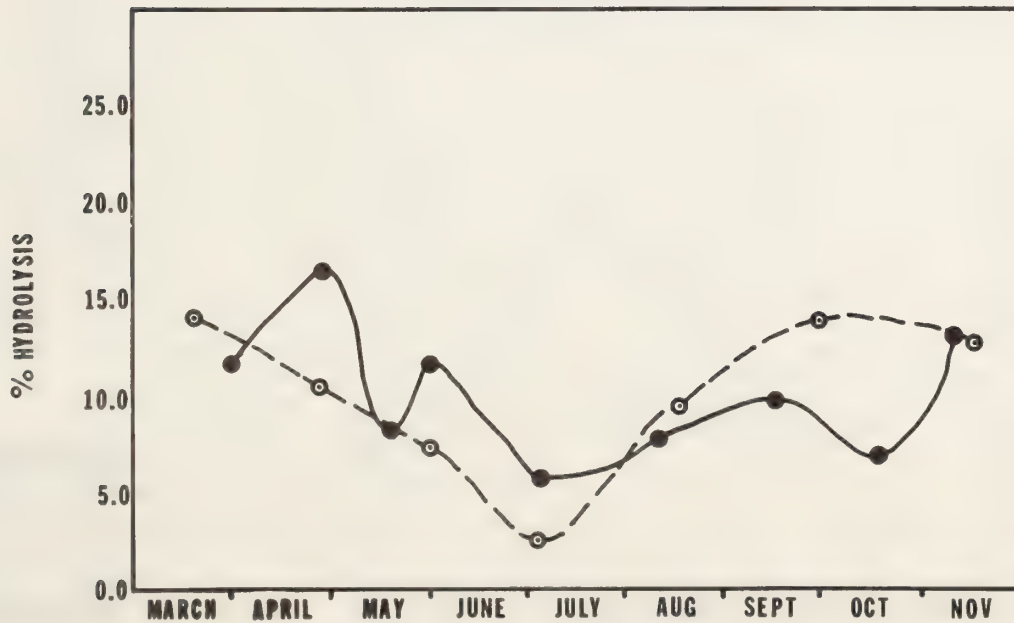




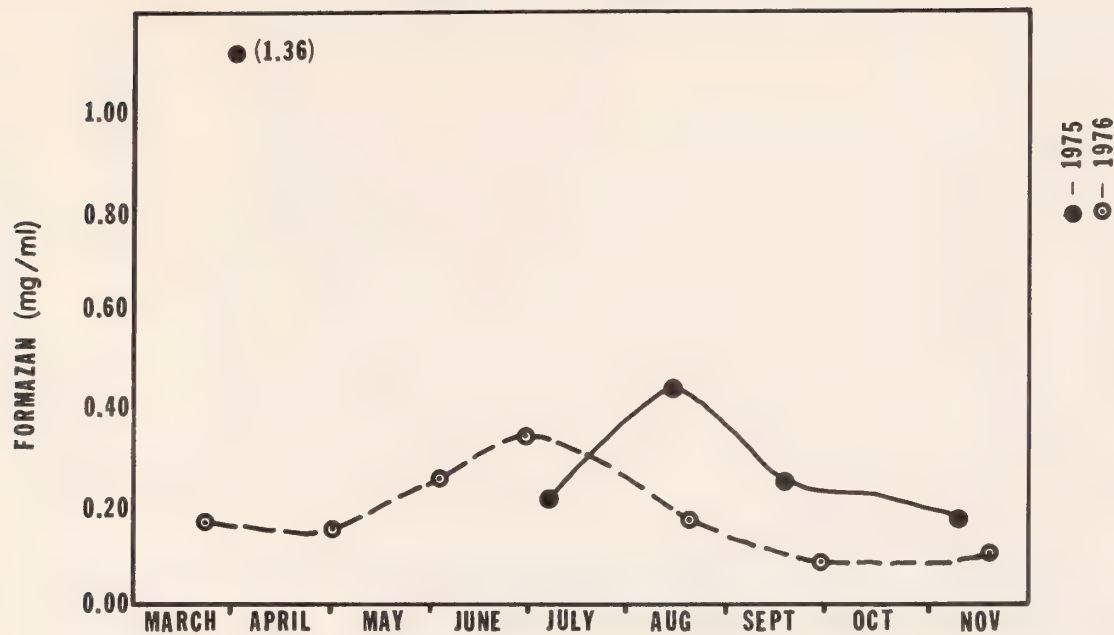
RESPIRATION



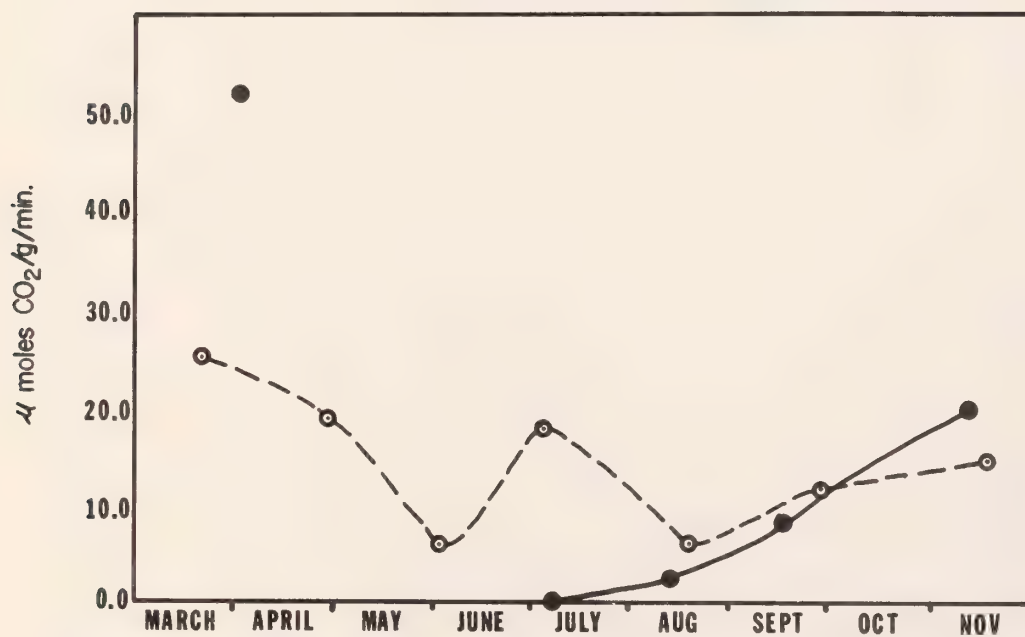
PROTEOLYTIC ACTIVITY



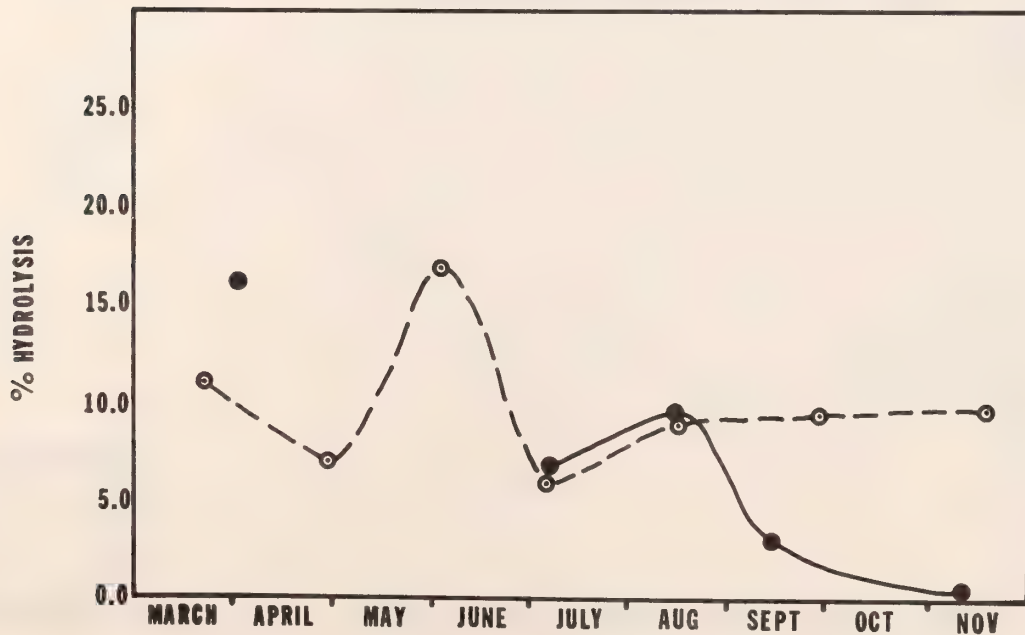
DEHYDROGENASE ACTIVITY



RESPIRATION

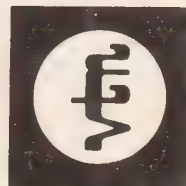


PROTEOLYTIC ACTIVITY

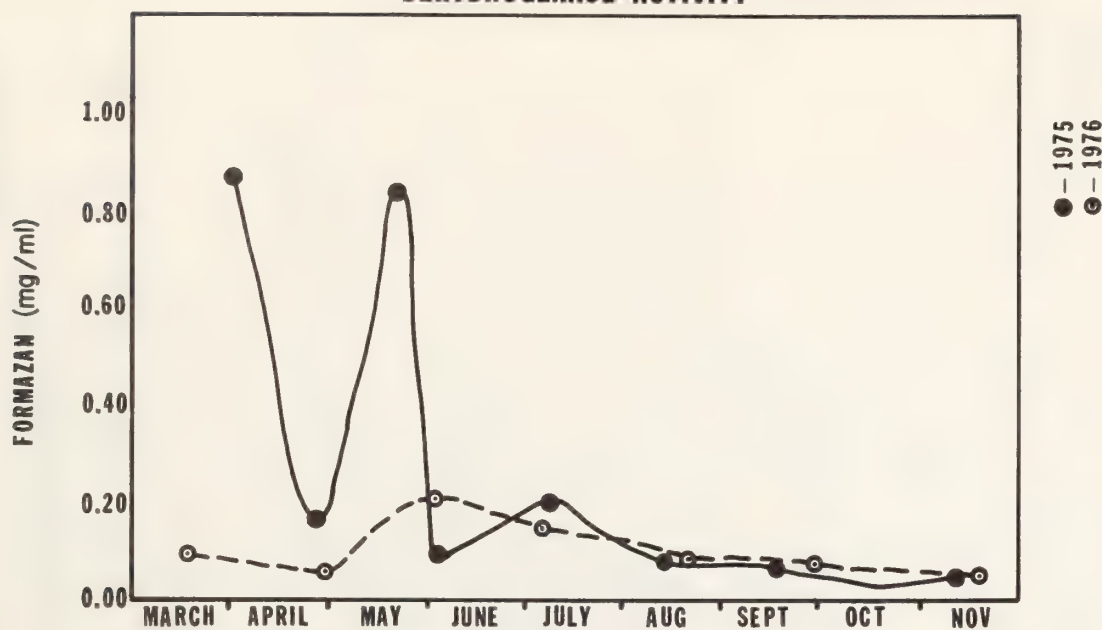


MICROBIAL ACTIVITIES IN SITE 58C SURFACE SOIL FOR 1975 AND 1976 SAMPLING DATES

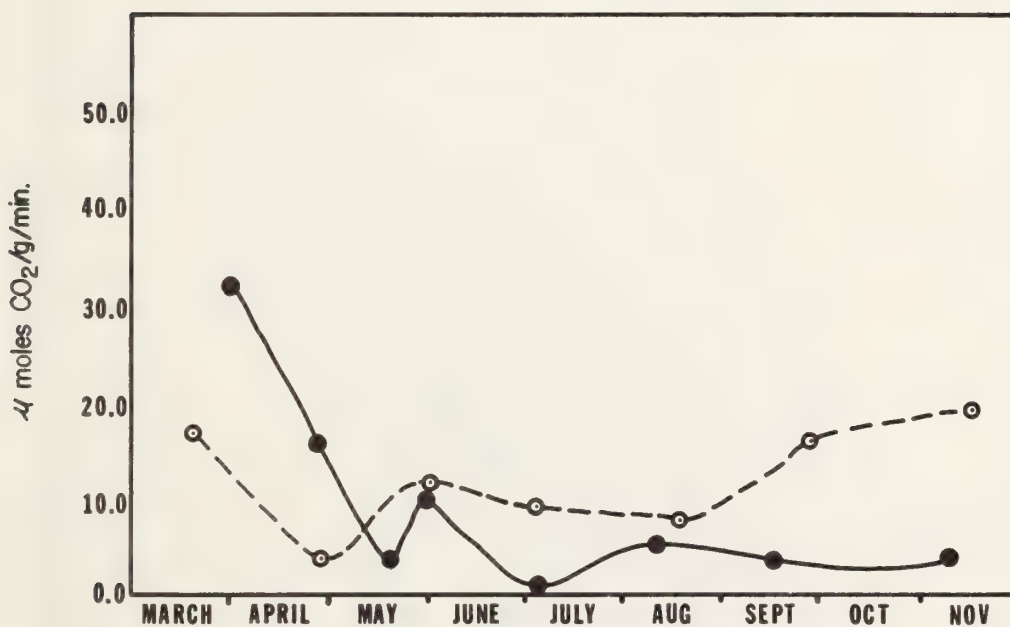
APPENDIX IV-49



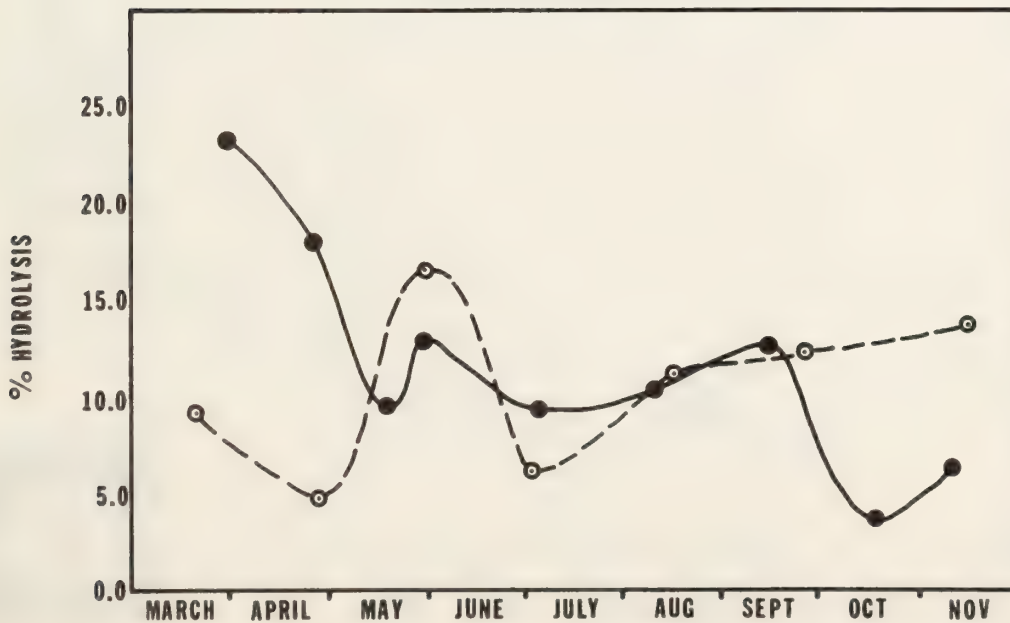
DEHYDROGENASE ACTIVITY



RESPIRATION



PROTEOLYTIC ACTIVITY

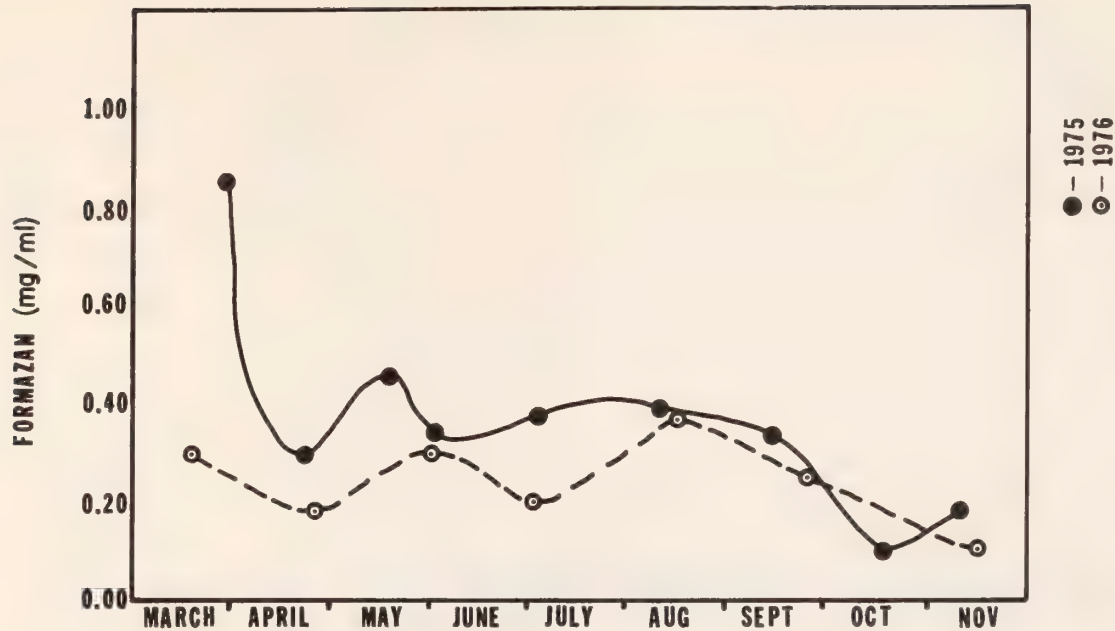


MICROBIAL ACTIVITIES IN SITE 581 SURFACE SOIL FOR 1975 AND 1976 SAMPLING DATES

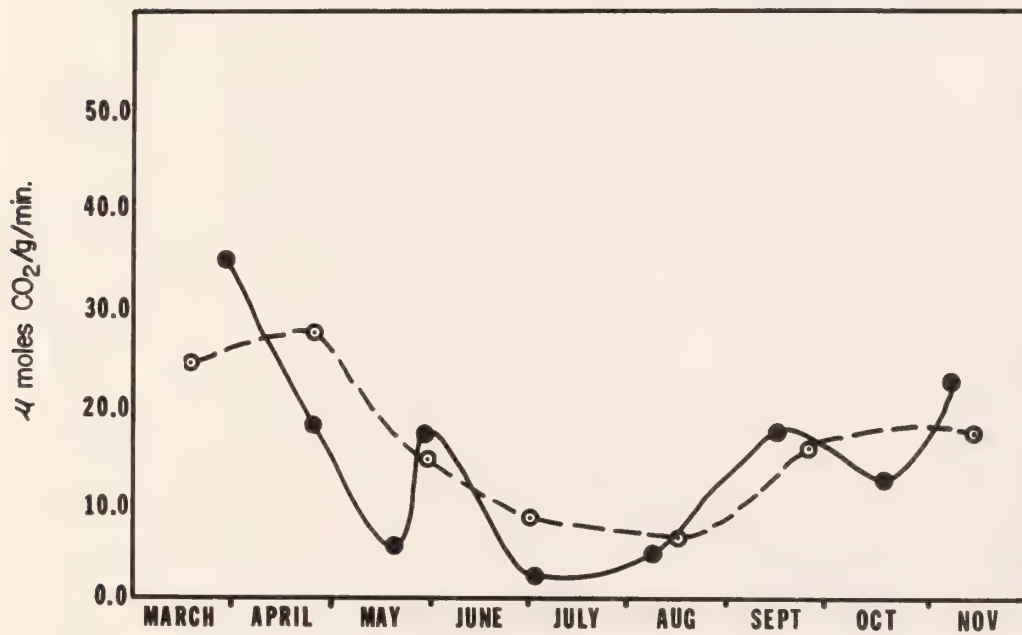
APPENDIX IV-50



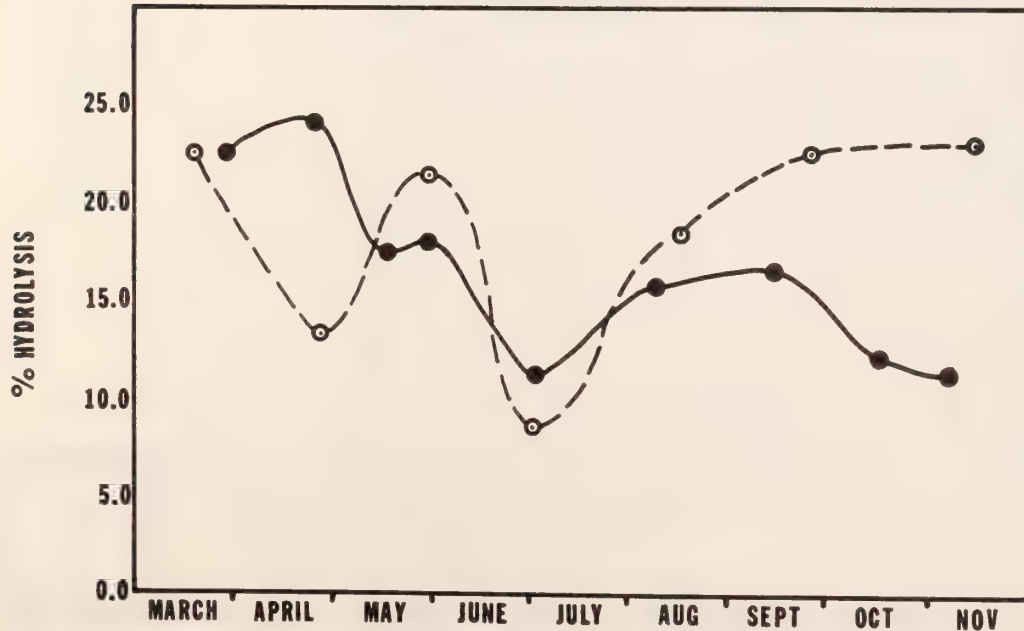
DEHYDROGENASE ACTIVITY



RESPIRATION



PROTEOLYTIC ACTIVITY



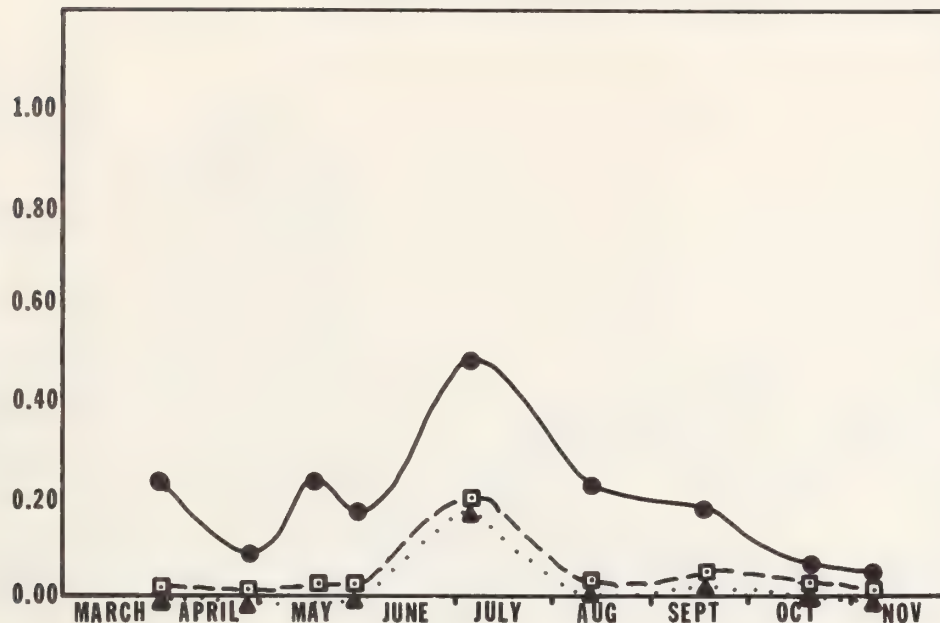
MEAN VALUES OF MICROBIAL ACTIVITIES FOR 1975 AND 1976 SAMPLING DATES FOR ALL SITES

APPENDIX IV-51



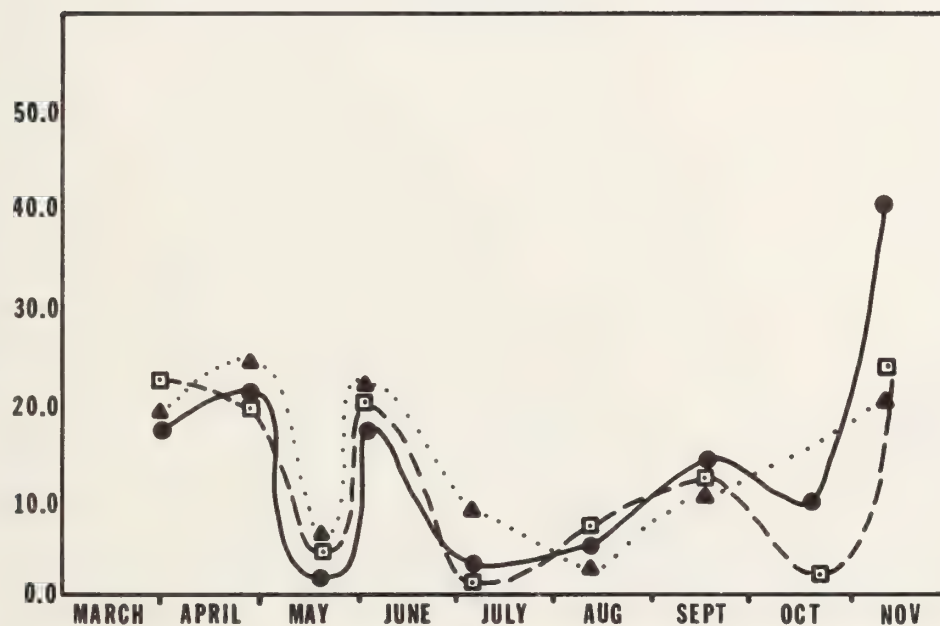
DEHYDROGENASE ACTIVITY

FORMAZAN (mg/ml)



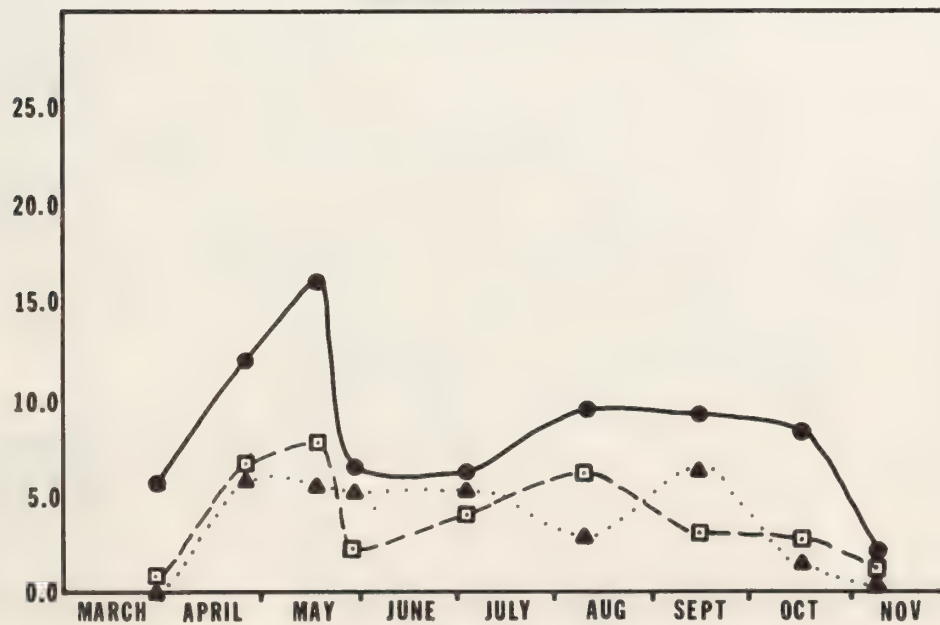
RESPIRATION

μ moles $\text{CO}_2/\text{g}/\text{min.}$



PROTEOLYTIC ACTIVITY

% HYDROLYSIS



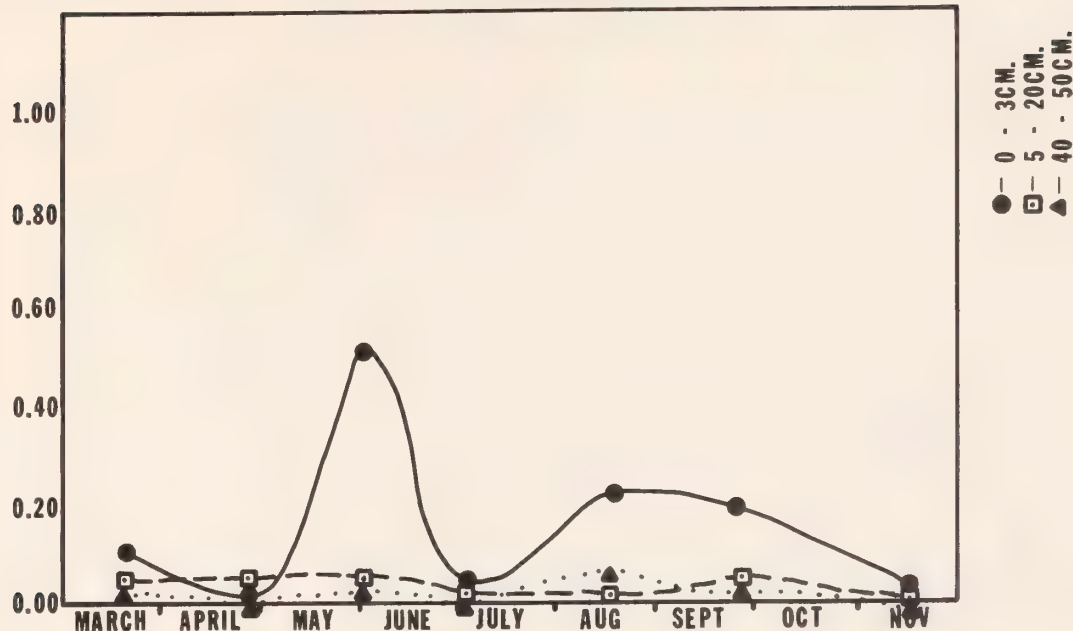
MICROBIAL ACTIVITIES AT THREE DIFFERENT DEPTHS OF SITE 39 FOR 1975 SAMPLES

APPENDIX IV-52



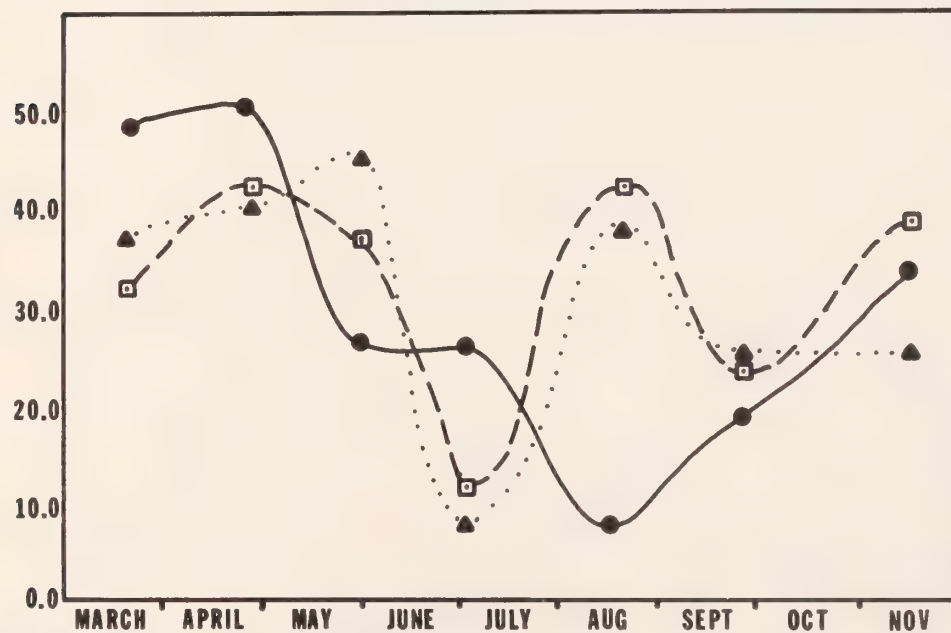
DEHYDROGENASE ACTIVITY

FORMAZAN (mg/ml)



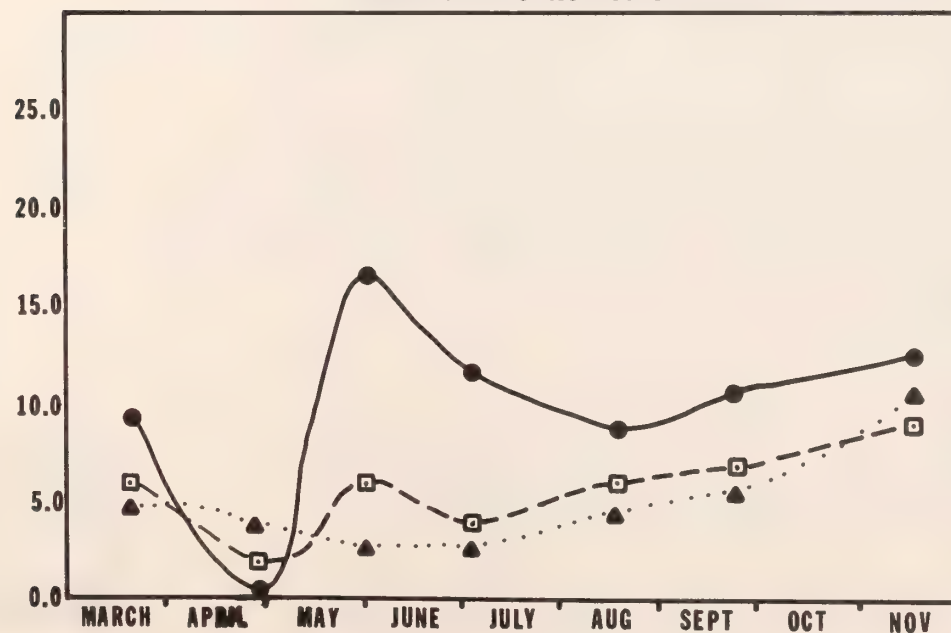
RESPIRATION

μ moles $CO_2/g/min.$



PROTEOLYTIC ACTIVITY

% HYDROLYSIS

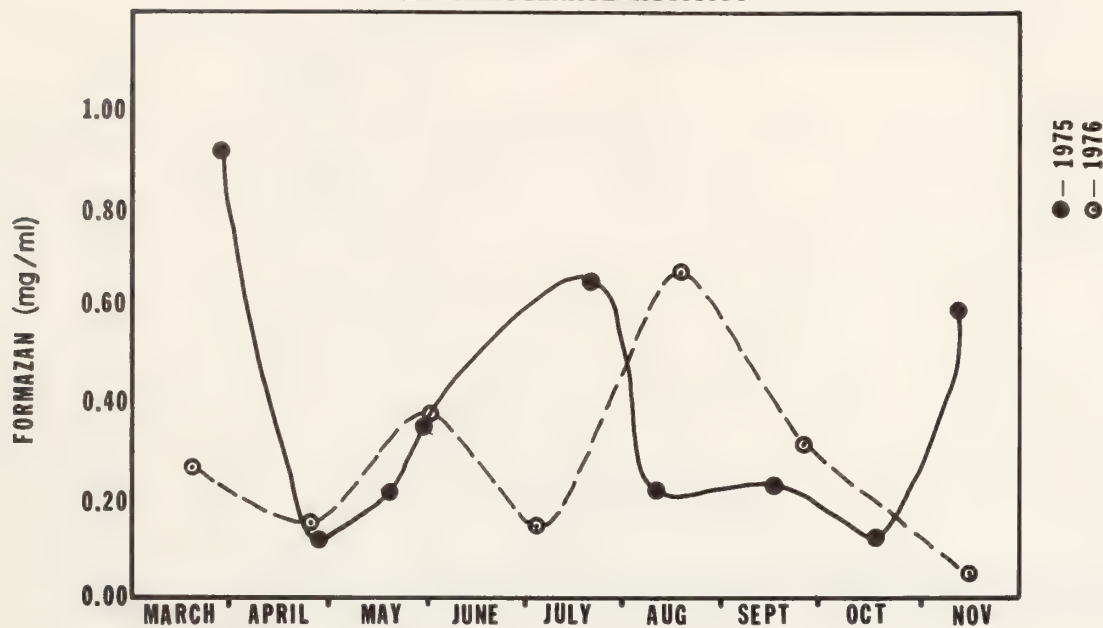


MICROBIAL ACTIVITIES AT THREE DIFFERENT DEPTHS OF SITE 39 FOR 1976 SAMPLES

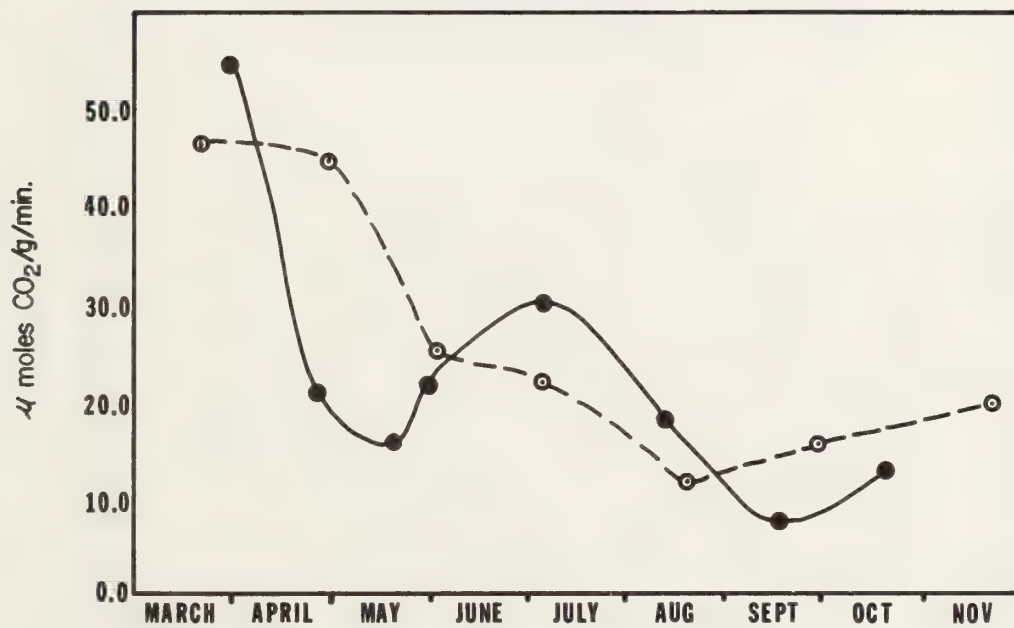
APPENDIX IV-53



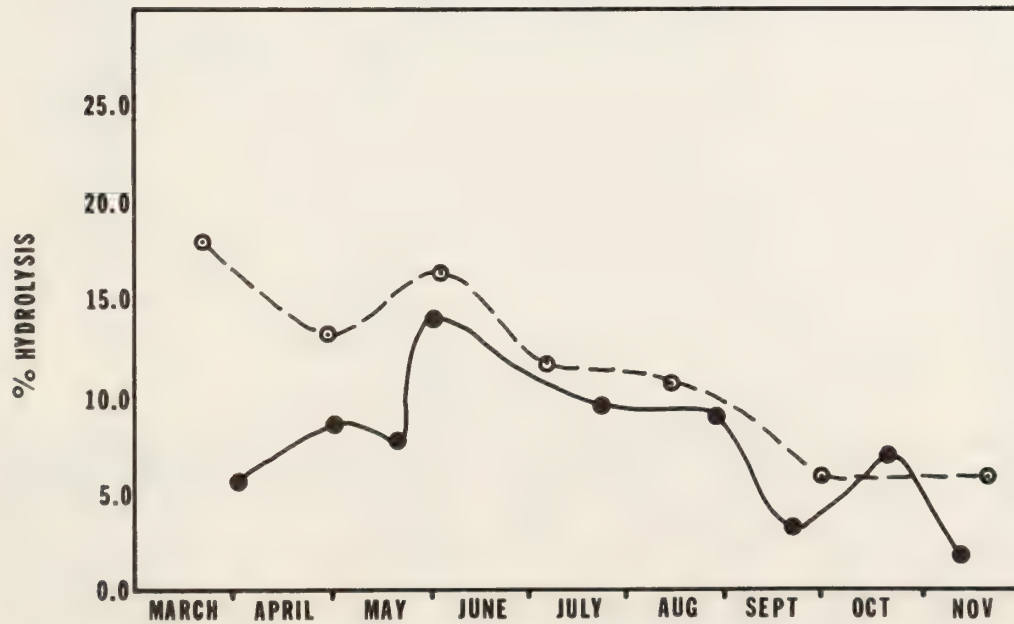
DEHYDROGENASE ACTIVITY



RESPIRATION



PROTEOLYTIC ACTIVITY

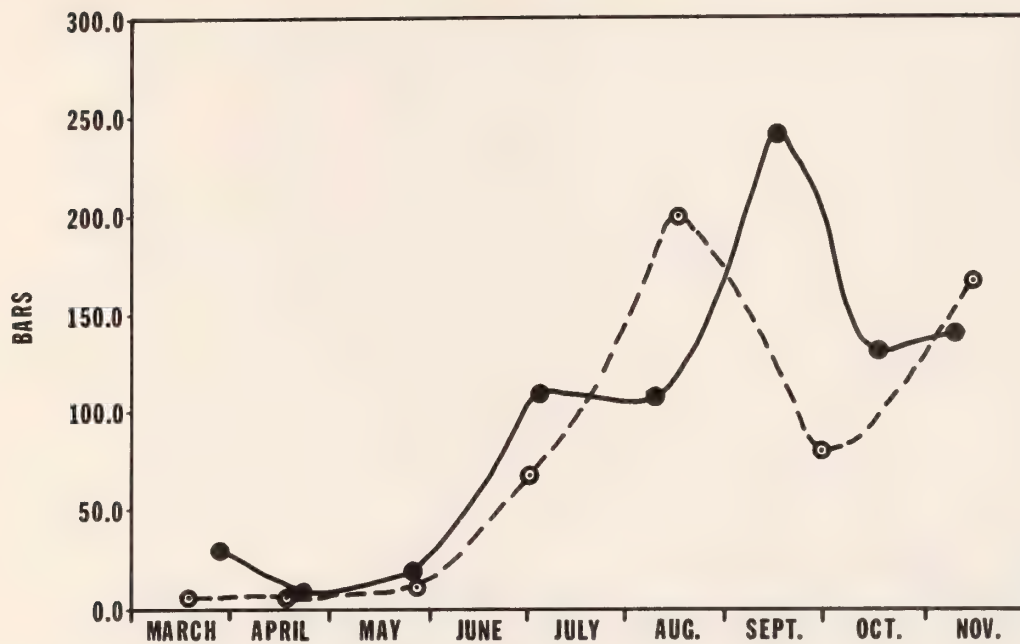


MICROBIAL ACTIVITIES IN SITE 55R SURFACE SOIL FOR 1975 AND 1976 SAMPLING DATES

APPENDIX IV-54



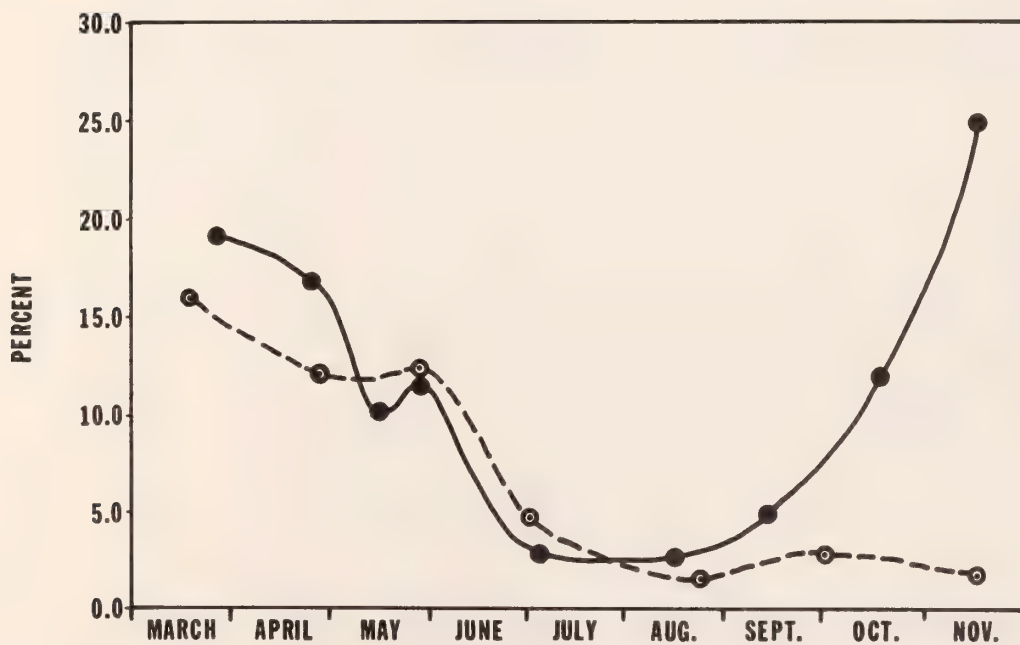
WATER POTENTIAL



● — 1975

○ — 1976

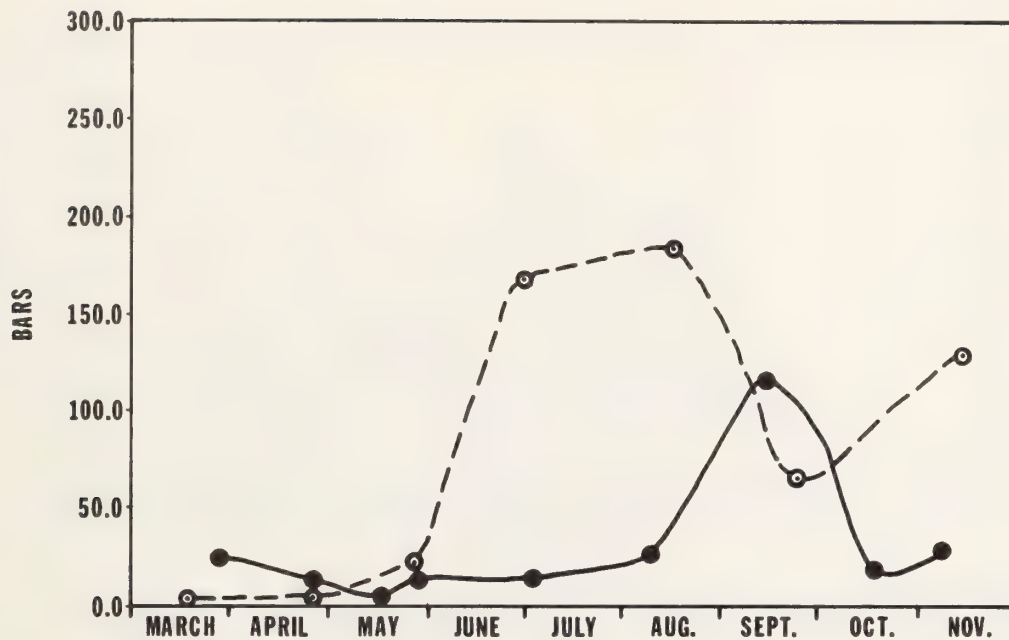
MOISTURE



MOISTURE AND WATER POTENTIAL AT SITE 39 FOR
1975 AND 1976 SAMPLING DATES

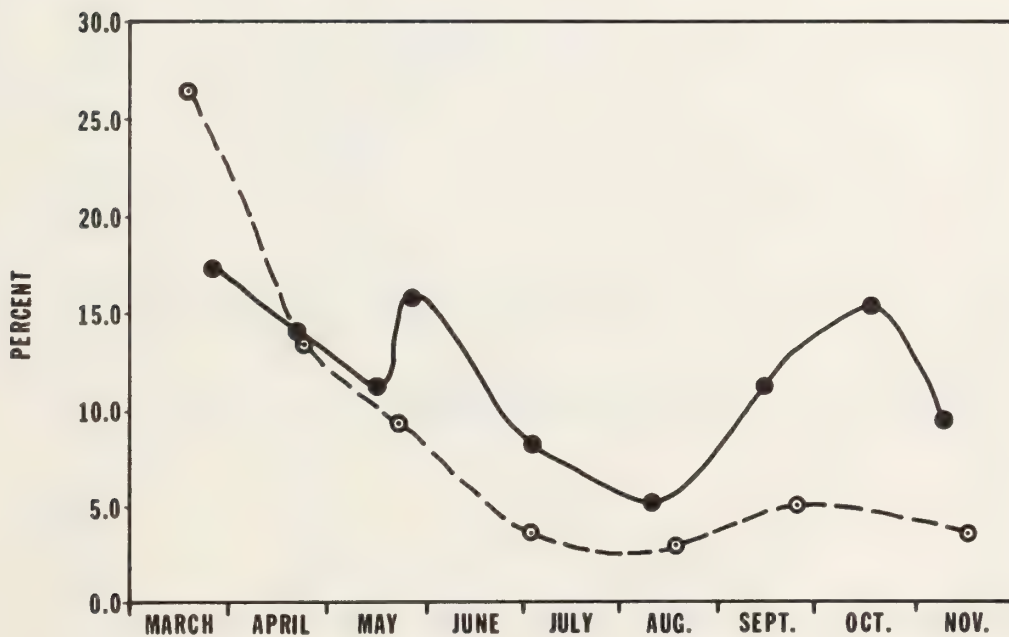


WATER POTENTIAL



● - 1975
○ - 1976

MOISTURE

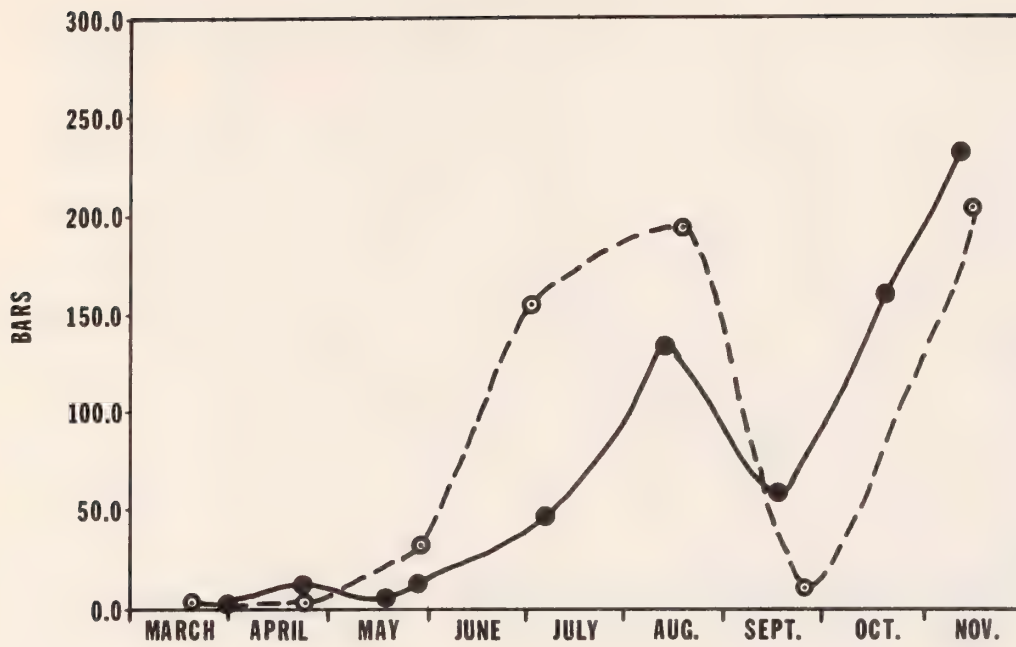


MOISTURE AND WATER POTENTIAL AT SITE 50JC FOR
1975 AND 1976 SAMPLING DATES

APPENDIX IV-56

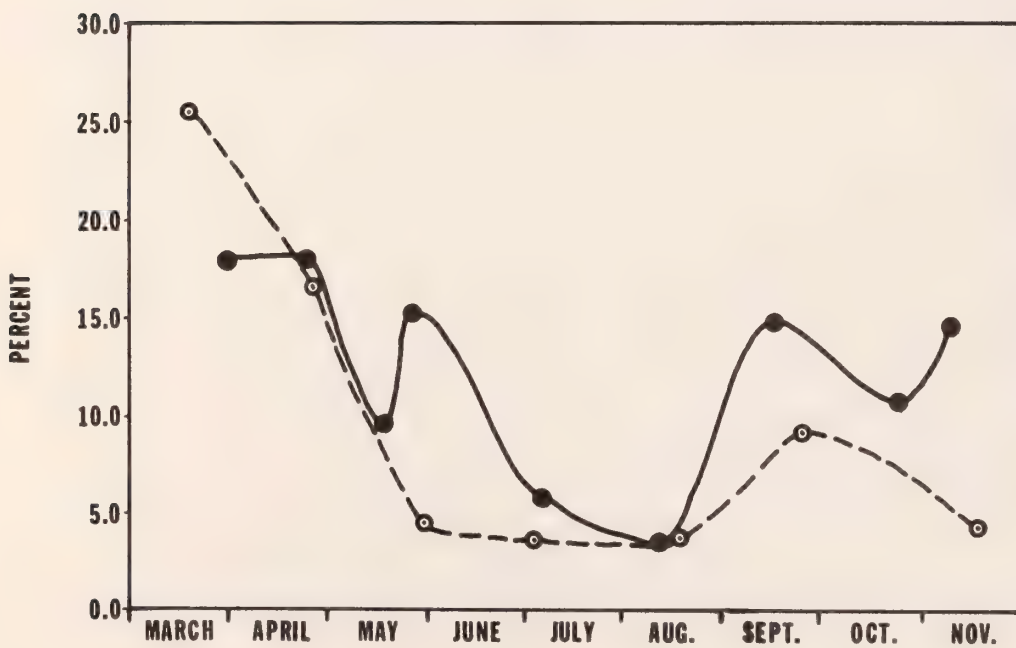


WATER POTENTIAL



● — 1975
○ — 1976

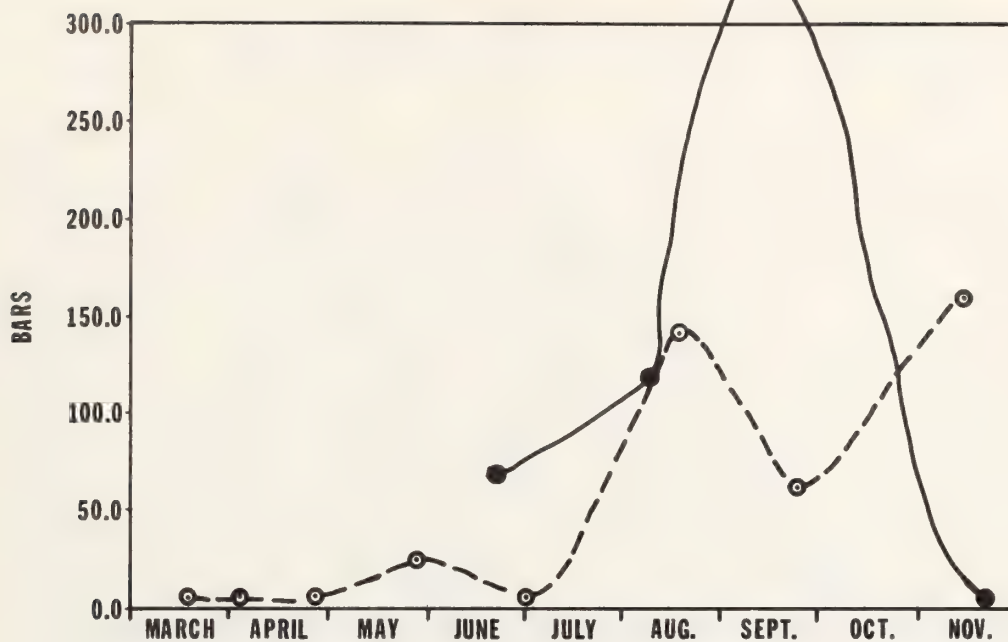
MOISTURE



**MOISTURE AND WATER POTENTIAL AT SITE 50J1 FOR
1975 AND 1976 SAMPLING DATES**

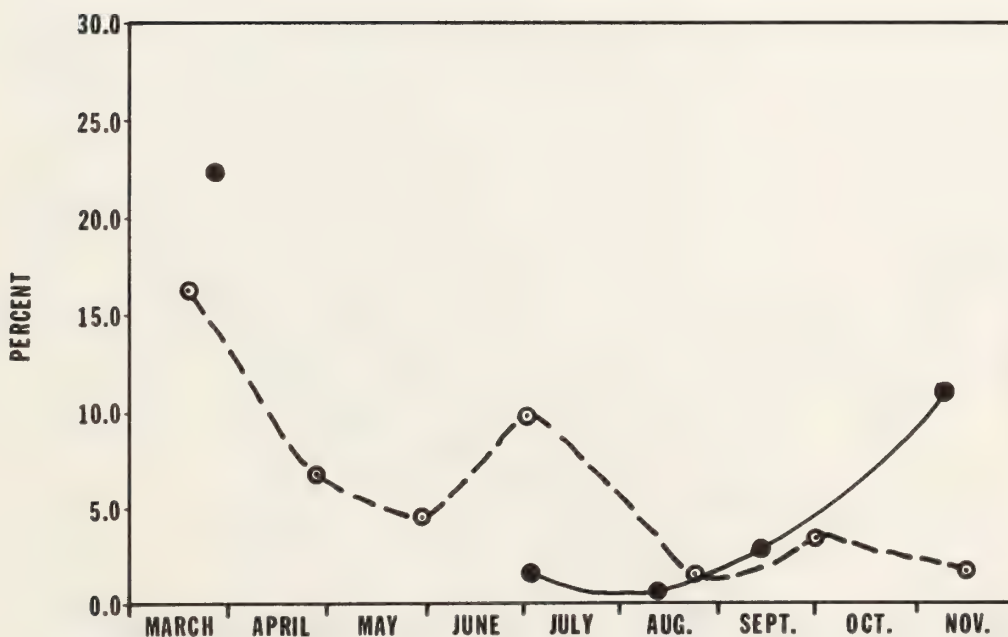


WATER POTENTIAL



● - 1975
○ - 1976

MOISTURE

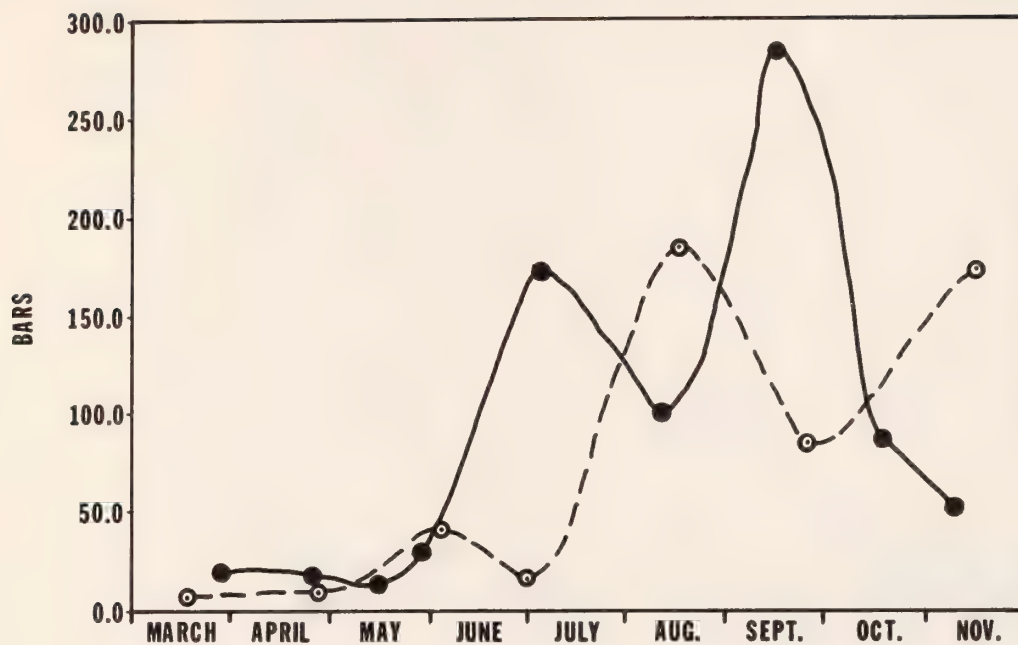


MOISTURE AND WATER POTENTIAL AT SITE 58C FOR
1975 AND 1976 SAMPLING DATES

APPENDIX IV-58

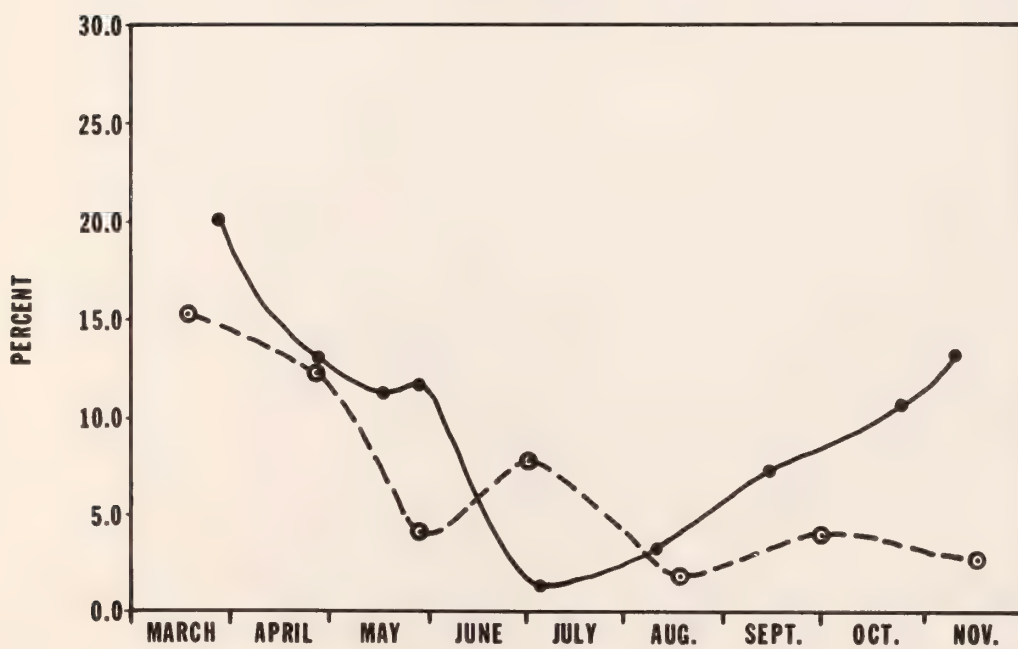


WATER POTENTIAL



● - 1975
○ - 1976

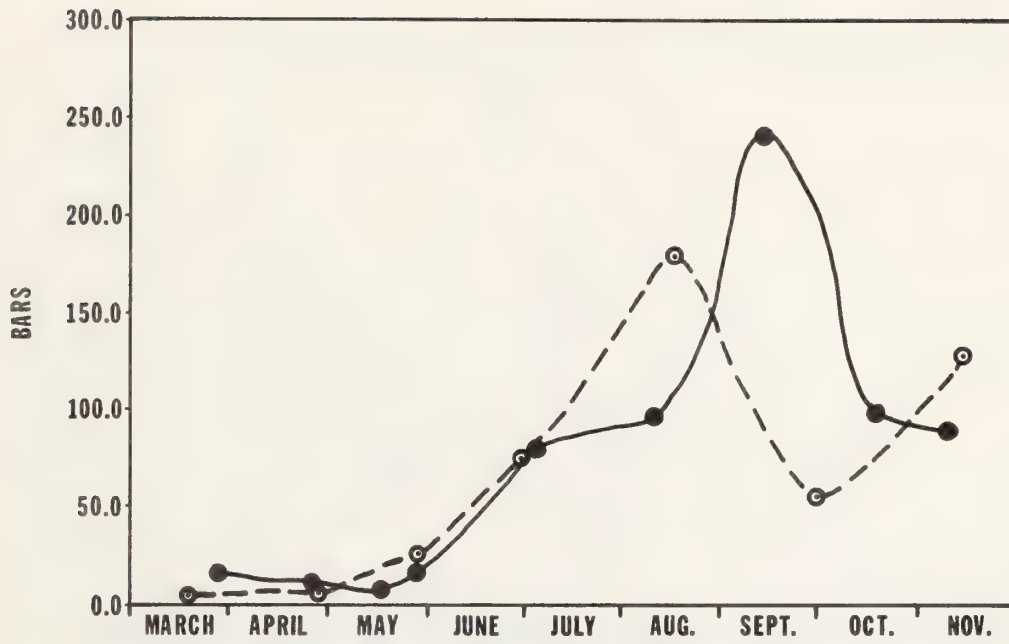
MOISTURE



MOISTURE AND WATER POTENTIAL AT SITE 581 FOR
1975 AND 1976 SAMPLING DATES

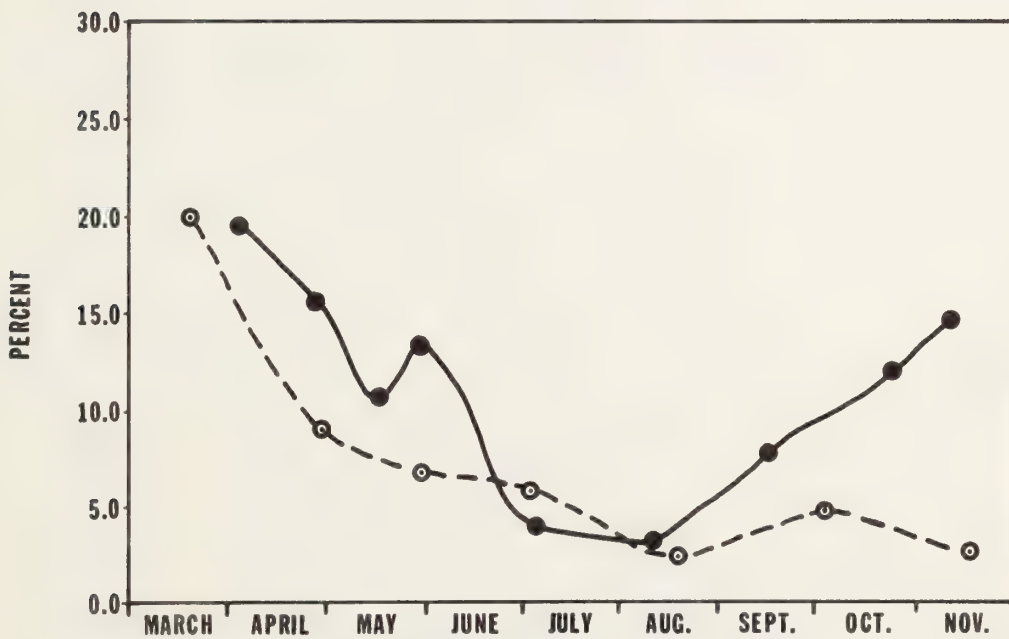


WATER POTENTIAL



● - 1975
○ - 1976

MOISTURE

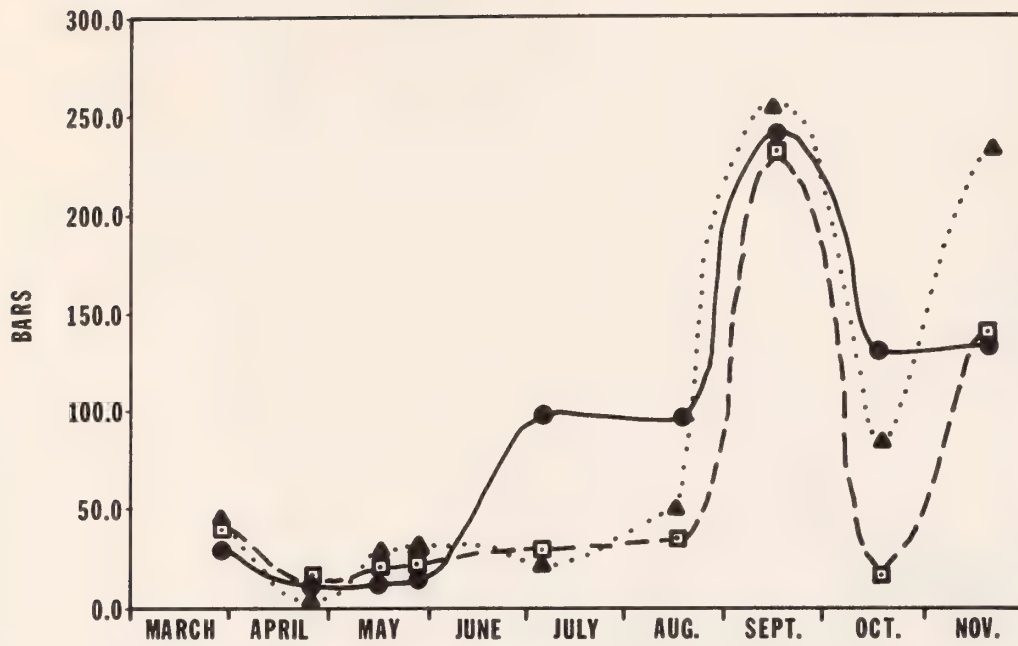


MEAN VALUES OF MOISTURE AND WATER POTENTIAL FOR
1975 AND 1976 SAMPLING DATES FOR ALL SITES

APPENDIX IV-60

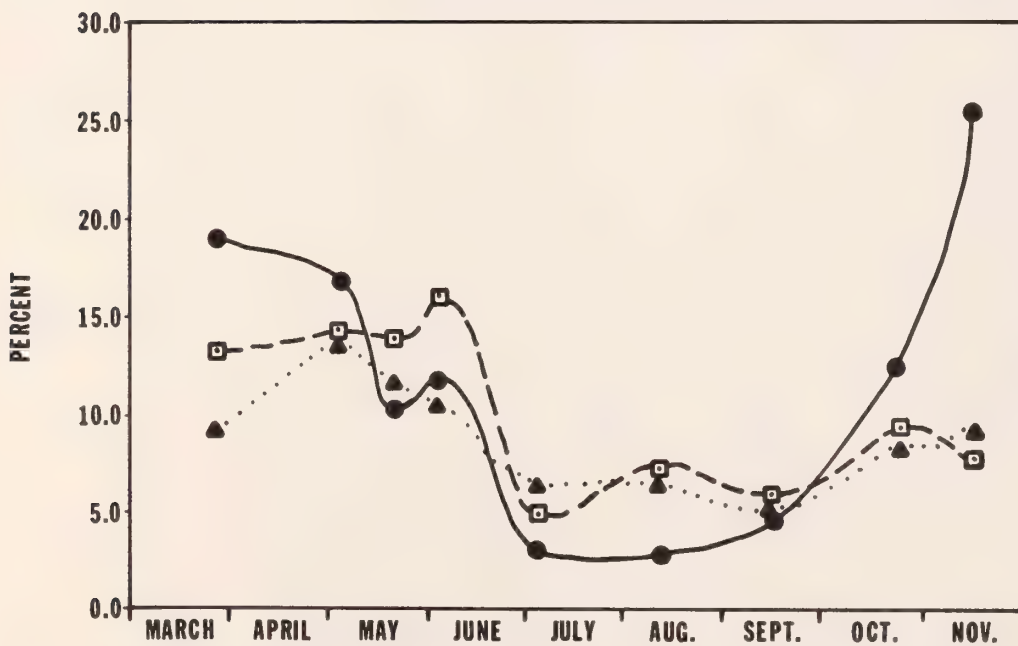


WATER POTENTIAL



- — SURFACE - 3CM.
- — 5 - 20CM.
- ▲ — 40 - 50 CM.

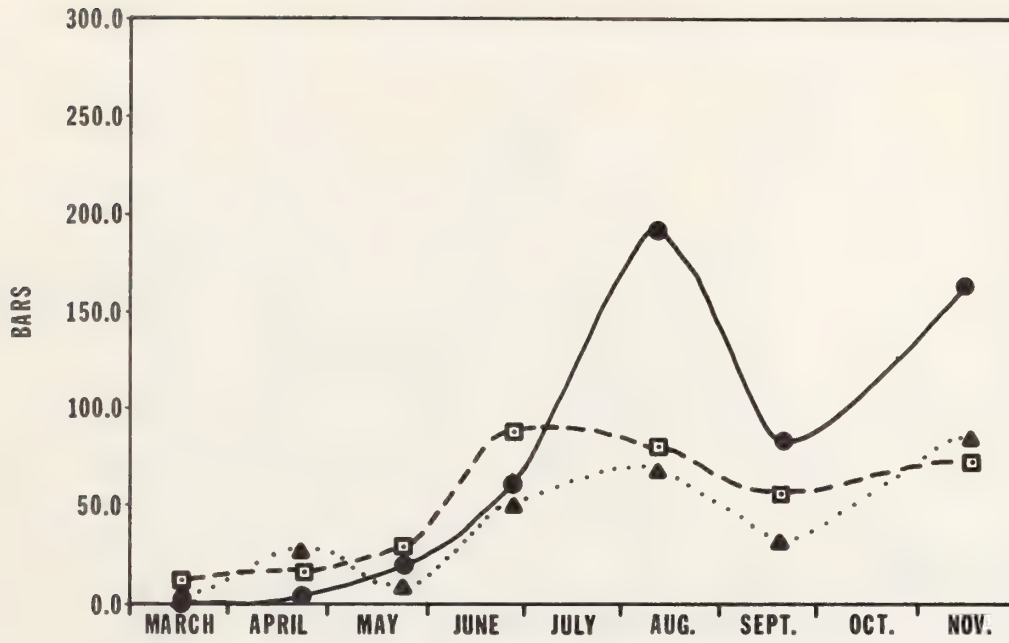
MOISTURE



MOISTURE AND WATER POTENTIAL AT THREE DIFFERENT DEPTHS OF SITE 39 FOR 1975

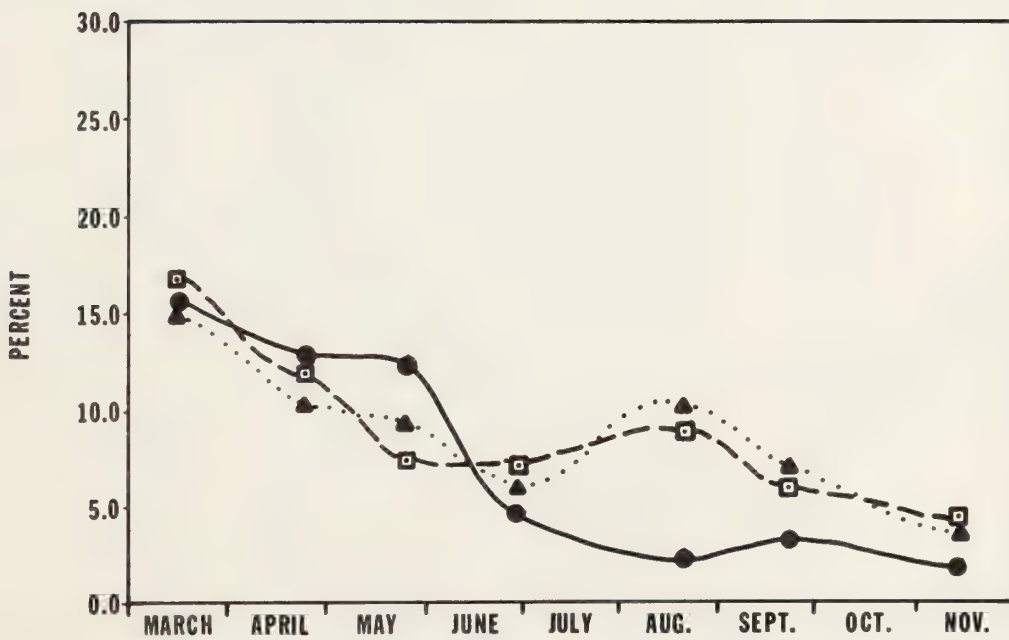


WATER POTENTIAL



● - SURFACE - 3CM.
 □ - 5 - 20CM.
 ▲ - 40 - 50CM.

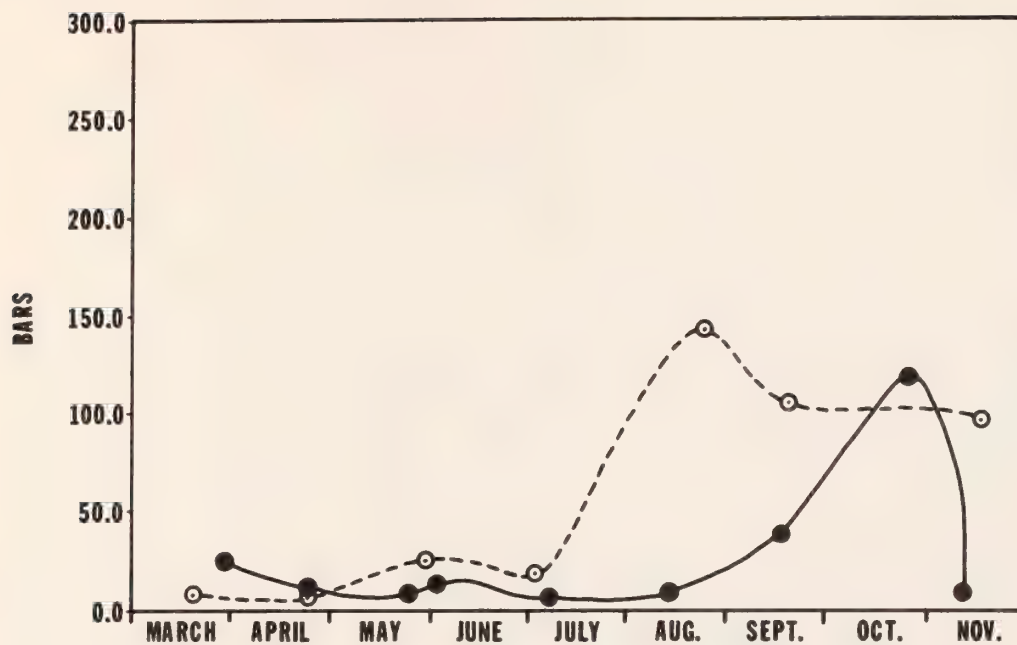
MOISTURE



**MOISTURE AND WATER POTENTIAL AT THREE DIFFERENT
DEPTHS OF SITE 39 FOR 1976**



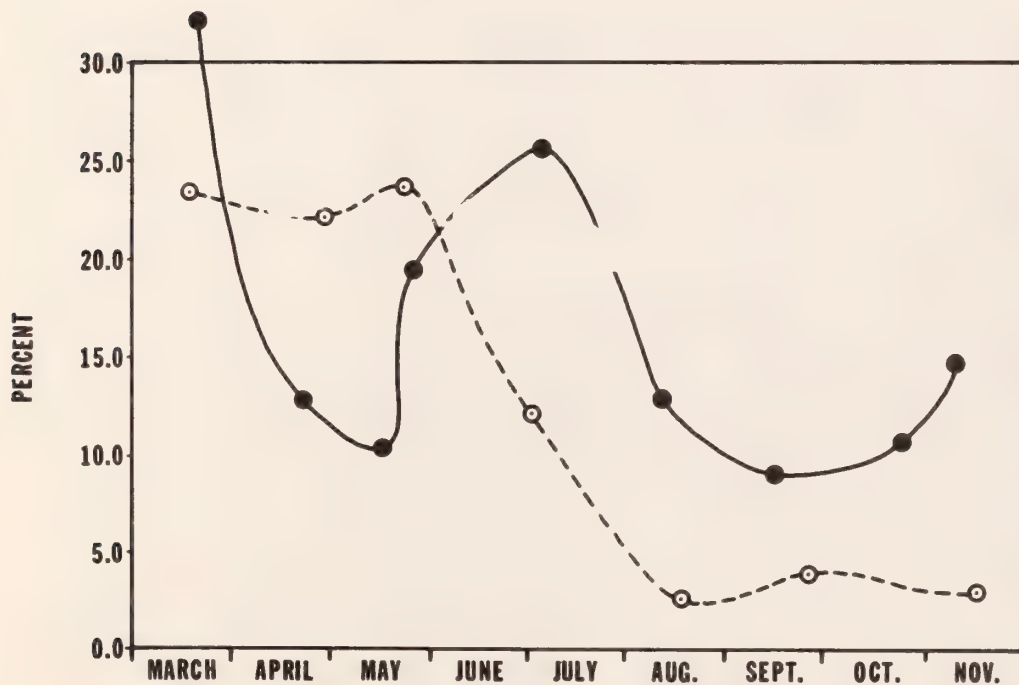
WATER POTENTIAL



● - 1975

○ - 1976

MOISTURE



MOISTURE AND WATER POTENTIAL AT SITE 55R
FOR 1975 AND 1976 SAMPLING DATES

APPENDIX IV-63



APPENDIX IV-64

pH Values

1975

Sample	March 28	April 25	May 16	May 27	July 2	August 8	September 12	October 13	November 6
39-1	8.7	8.2	8.2	9.4	8.9	8.7	8.5	8.3	8.8
39-2	8.4	8.2	8.1	8.2	8.8	8.6	8.4	8.3	8.6
39-3	8.7	8.4	8.4	8.4	8.8	8.6	8.4	8.6	8.8
50JC-1	8.0	7.8	7.8	8.3	8.6	8.4	8.2	8.0	7.5
50JC-1	7.8	8.0	8.1	8.0	8.4	8.6	8.0	7.3	7.4
55R-1	8.2	8.0	7.9	8.4	8.6	8.4	8.2	7.8	8.3
55R-2	7.8	8.7	8.3	8.2	8.6	8.8	8.2	8.5	-
55R-3	8.1	8.3	8.1	8.3	8.6	8.6	8.2	8.7	8.1
58C-1	8.1	-	-	-	9.7	9.1	9.4	-	8.4
58C-2	8.4	-	-	-	9.9	9.4	9.4	-	9.4
58C-3	8.4	-	-	-	9.9	9.6	9.3	-	9.6
581-1	8.1	8.4	8.4	8.3	8.9	8.7	8.6	8.2	7.7
581-2	8.5	8.6	8.1	8.5	9.8	8.9	9.4	8.4	7.5
581-3	8.7	9.1	8.8	8.6	10.1	8.9	9.7	8.1	7.4
50JC-1	7.7	-	-	-	-	8.0	7.9	-	7.1
58C-L	-	-	-	-	-	9.0	-	-	7.6

APPENDIX IV-65

pH Values

1976

Sample	March 18	April 26	May 28	June 30	August 13	September 23	November 12
39-1	8.5	9.0	7.9	8.8	8.3	8.3	7.7
39-2	8.6	7.9	8.2	8.2	8.9	8.6	8.0
39-3	8.2	7.7	8.3	8.2	8.8	8.6	7.9
50JC-1	8.1	8.2	7.6	7.7	6.9	7.3	7.5
50JI-1	8.4	8.0	7.7	7.8	7.8	7.6	7.2
55R-1	8.3	8.2	8.2	8.6	7.9	8.0	7.8
55R-2	8.3	8.2	8.3	8.4	8.1	8.2	8.1
55R-3	8.1	8.4	8.3	8.4	8.2	8.2	7.8
58C-1	8.5	9.9	9.0	8.1	9.1	8.6	8.7
58C-2	8.5	9.6	9.6	9.0	9.4	8.7	8.2
58C-3	8.9	9.7	9.7	9.0	9.5	8.8	7.8
58I-1	8.4	8.2	7.7	8.2	8.2	7.3	7.4
58I-2	8.8	9.0	8.1	8.3	8.9	8.1	7.4
58I-3	8.5	9.3	8.1	8.4	9.2	7.1	7.5
50JC-L	8.0	-	8.0	6.9	7.2	7.4	6.8
58C-L	8.3	-	9.3	-	-	-	-

APPENDIX IV-66

Total Ammonium Nitrogen

(μg N/g soil)

1976

Sample	March 18	April 26	May 28	June 30	August 13	September 23	November 12
39-1	24.6	17.9	41.3	43.0	33.8	27.4	27.4
39-2	27.2	18.0	39.0	82.3	34.1	23.1	23.7
39-3	19.4	15.4	31.2	59.0	22.2	32.4	12.0
50JC-1	109.0	109.6	119.0	254.9	82.4	66.5	133.2
50JI-1	81.3	96.5	71.9	222.5	99.9	76.0	100.4
55R-1	74.5	67.9	77.3	95.2	47.2	20.7	58.1
55R-2	17.6	21.0	31.2	69.6	14.1	22.2	44.4
55R-3	29.8	20.1	30.3	46.1	15.2	31.2	27.6
58C-1	30.8	30.6	84.2	107.3	61.3	53.8	38.2
58C-2	22.2	19.6	50.3	76.1	35.2	39.6	14.0
58C-3	19.6	10.5	30.9	67.0	32.8	58.4	11.2
58I-1	18.1	27.5	23.6	90.7	19.2	22.9	26.2
58I-2	19.0	13.8	15.7	31.4	15.6	16.8	16.2
58I-3	15.1	16.0	15.6	41.0	14.5	10.5	15.1
50JC-1	227.5	-	325.3	670.3	55.9	270.7	325.8
58C-L	228.5	-	704.0	-	-	-	-

APPENDIX IV-67

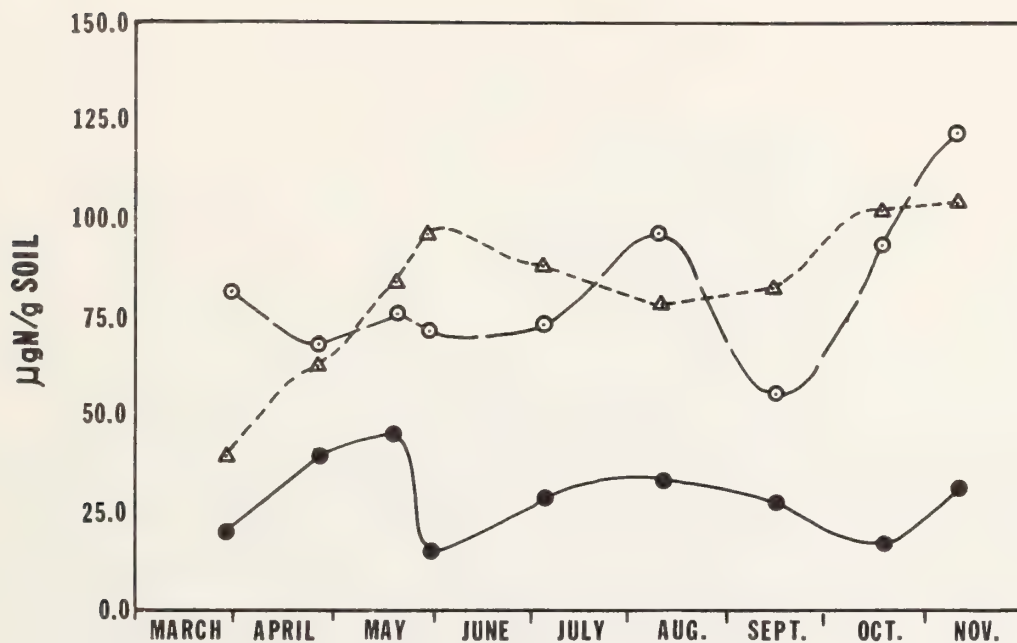
Total Ammonium Nitrogen

(µg N/g soil)

1975

Sample	March 28	April 25	May 16	May 27	July 2	August 8	September 12	October 13	November 6
39-1	28.1	39.0	54.2	15.5	27.3	30.9	31.6	25.0	54.2
39-2	18.9	16.7	33.0	14.6	12.5	29.8	24.1	11.3	33.0
39-3	3.8	14.3	28.2	9.3	15.5	19.9	22.1	11.5	28.2
50JC-1	93.3	62.1	80.8	70.4	71.5	93.2	62.9	104.2	90.0
50JI-1	59.9	80.4	90.0	93.6	86.3	75.8	85.7	105.8	89.6
55R-1	50.8	31.4	54.4	54.8	73.2	47.0	15.3	62.7	54.4
55R-2	10.2	15.2	22.2	11.3	37.9	14.7	20.2	-	22.2
55R-3	4.4	8.3	9.9	14.1	37.0	13.3	42.0	21.5	9.9
58C-1	42.0	-	-	-	41.3	61.2	52.0	33.0	-
58C-2	9.5	-	-	-	14.7	32.9	39.0	16.2	-
58C-3	4.5	-	-	-	13.8	31.6	59.1	15.3	-
58I-1	42.5	30.6	30.9	21.7	36.0	18.7	26.3	22.3	30.9
58I-2	11.1	14.0	21.9	14.6	15.7	14.8	20.9	14.6	21.9
58I-3	6.8	17.0	15.6	12.4	17.2	11.0	12.0	8.2	15.6
50JC-L	349.3	-	-	-	-	-	33.6	-	-
58C-L	-	-	-	-	-	-	-	-	-

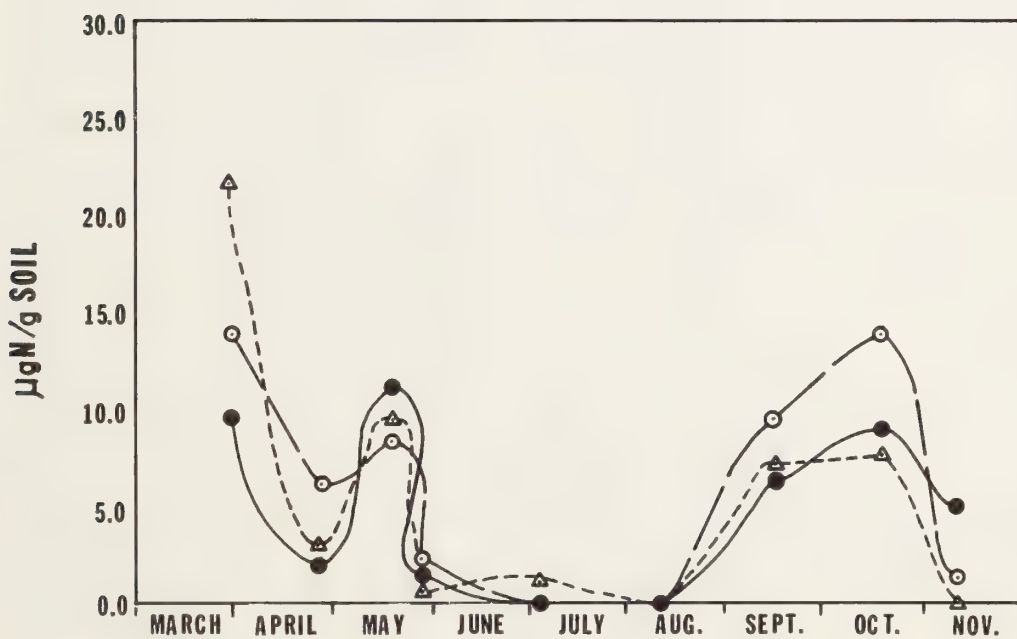
FIXED NH_4^+



SITE

- 39-1
- 50JC-1
- △ 50JI-1

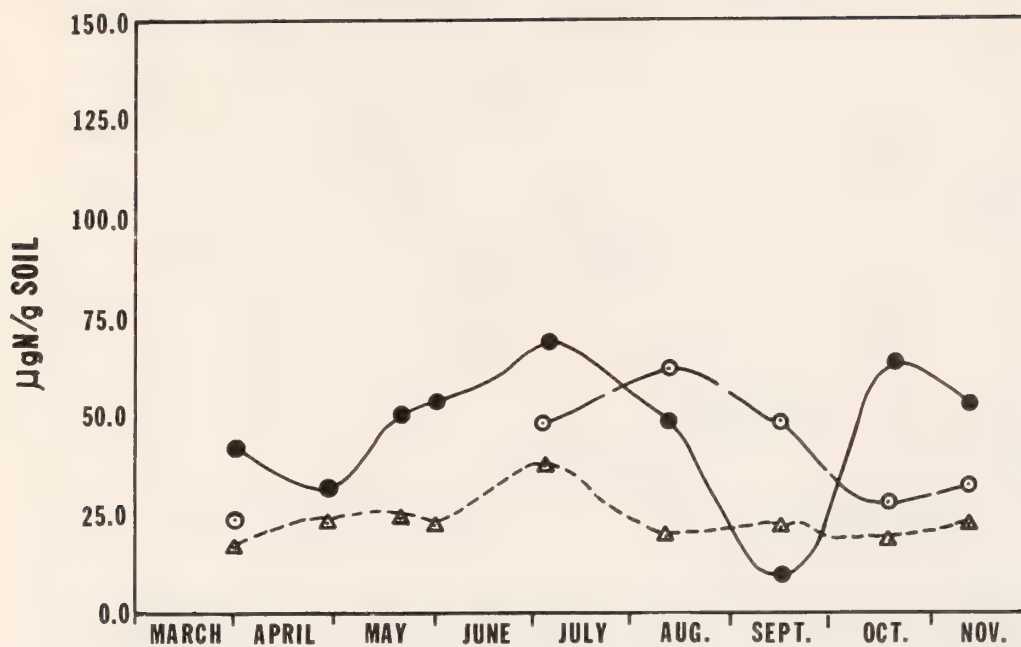
EXCHANGEABLE NH_4^+



FIXED AND EXCHANGEABLE AMMONIUM
IN THE SURFACE SOIL OF THREE SITES
FOR 1975 SAMPLING DATES



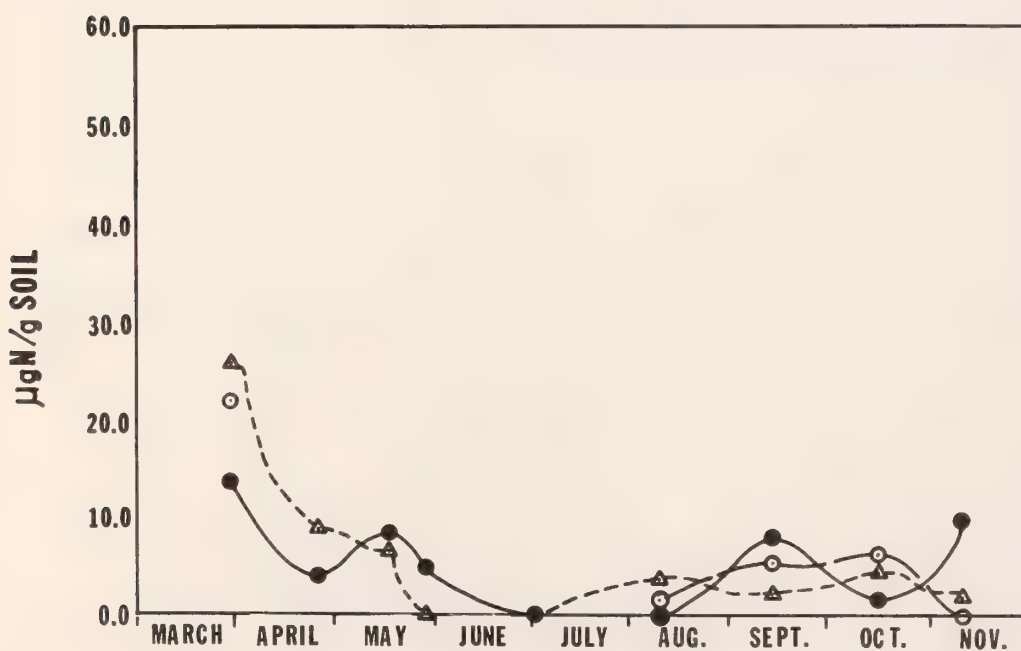
FIXED NH_4^+



SITE

- 55R-1
- 58C-1
- △ 58 I-1

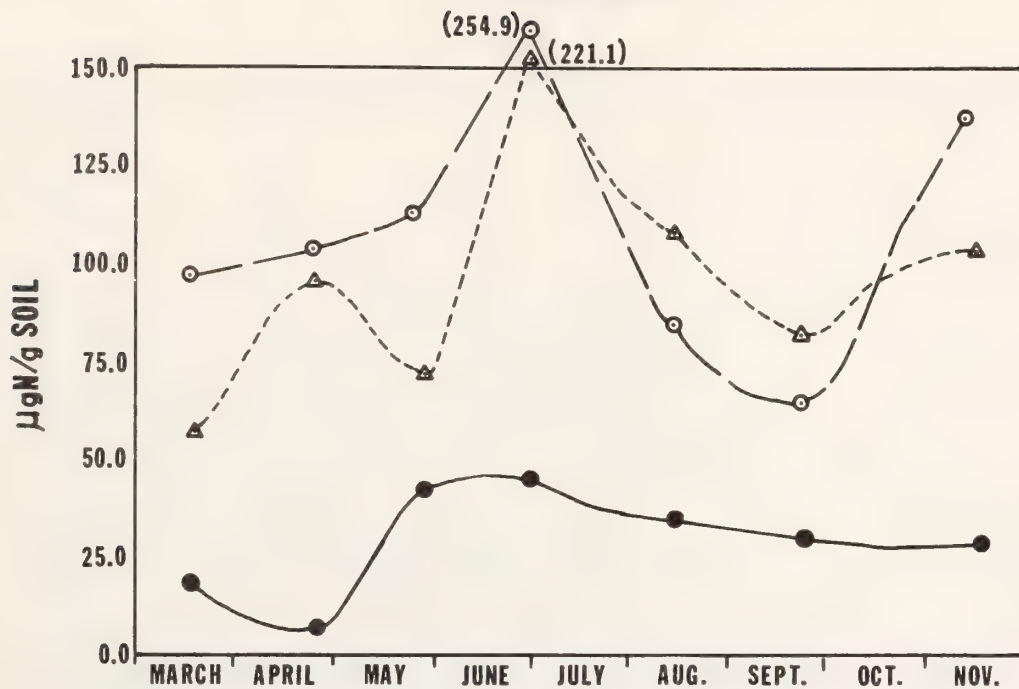
EXCHANGEABLE NH_4^+



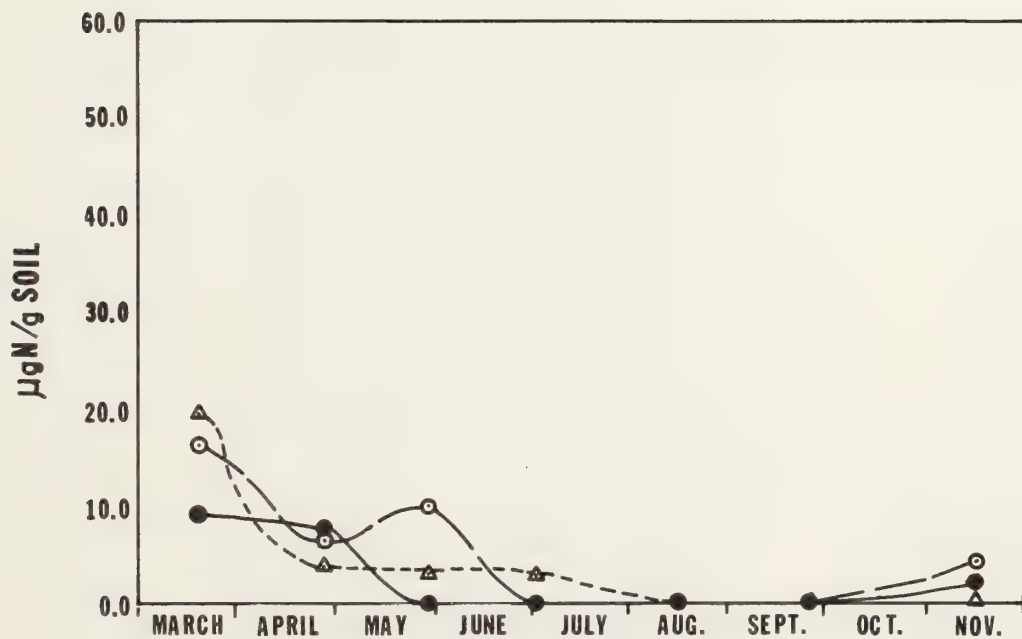
FIXED AND EXCHANGEABLE AMMONIUM
IN THE SURFACE SOIL OF THREE SITES
FOR 1975 SAMPLING SITES



FIXED NH_4^+



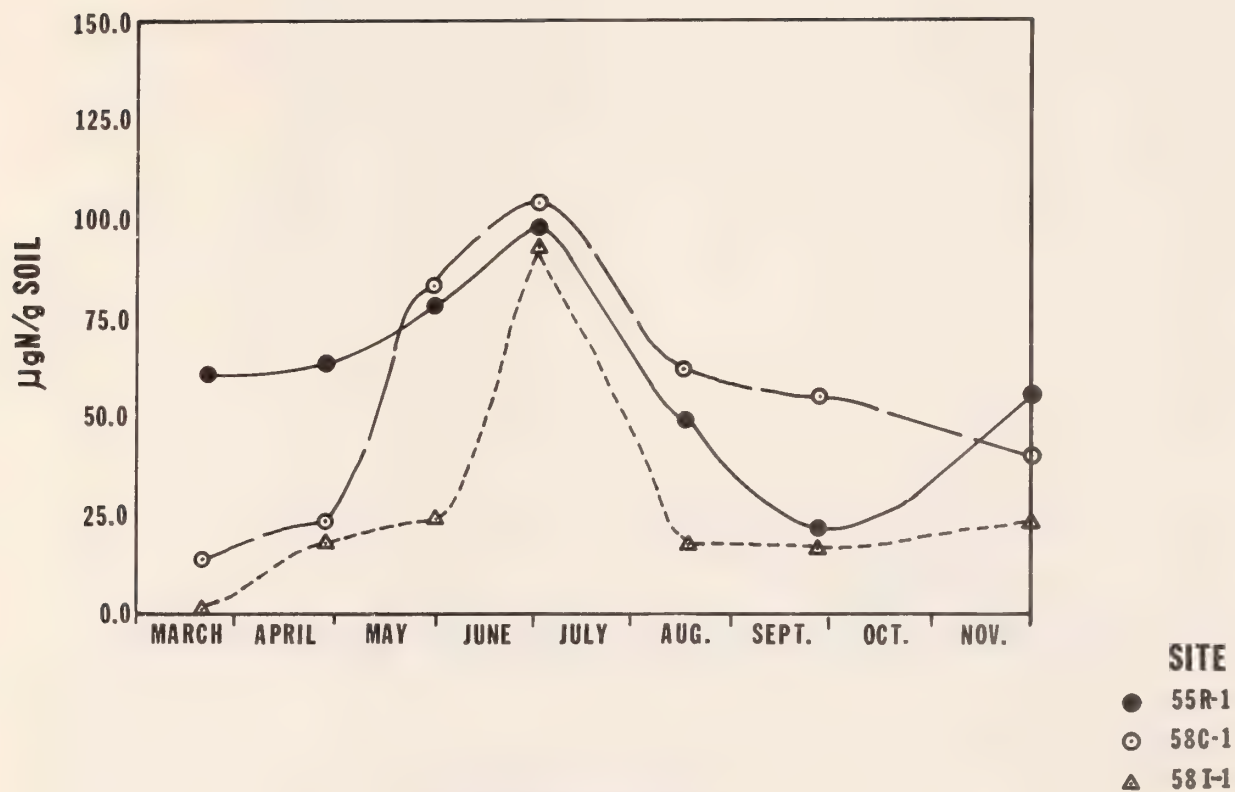
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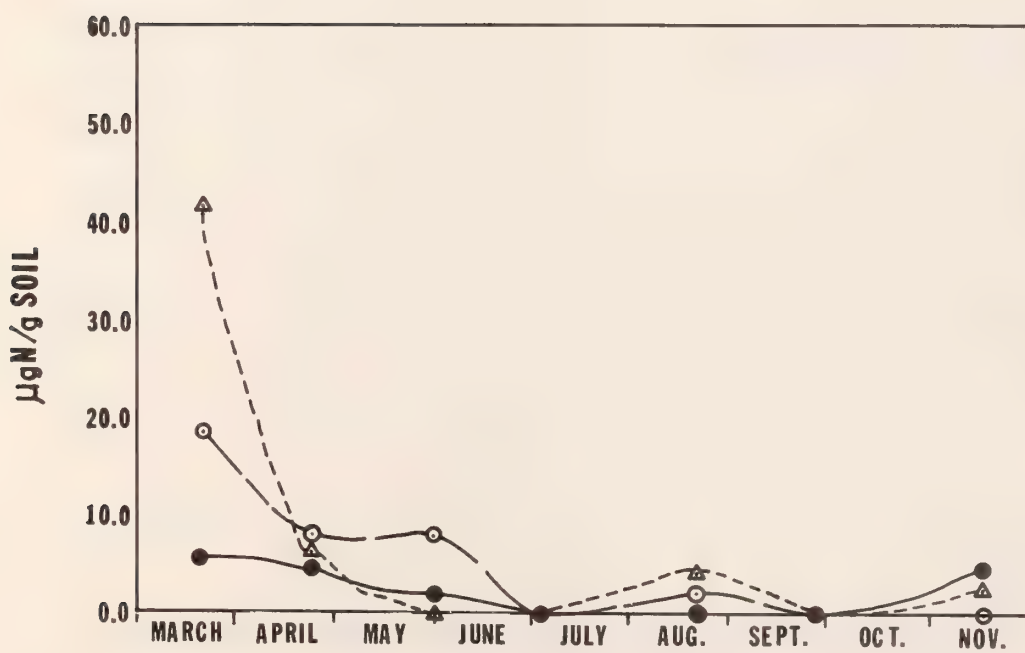
FIXED AND EXCHANGEABLE AMMONIUM
IN THE SURFACE SOIL OF THREE SITES
FOR 1976 SAMPLING DATES



FIXED NH_4^+



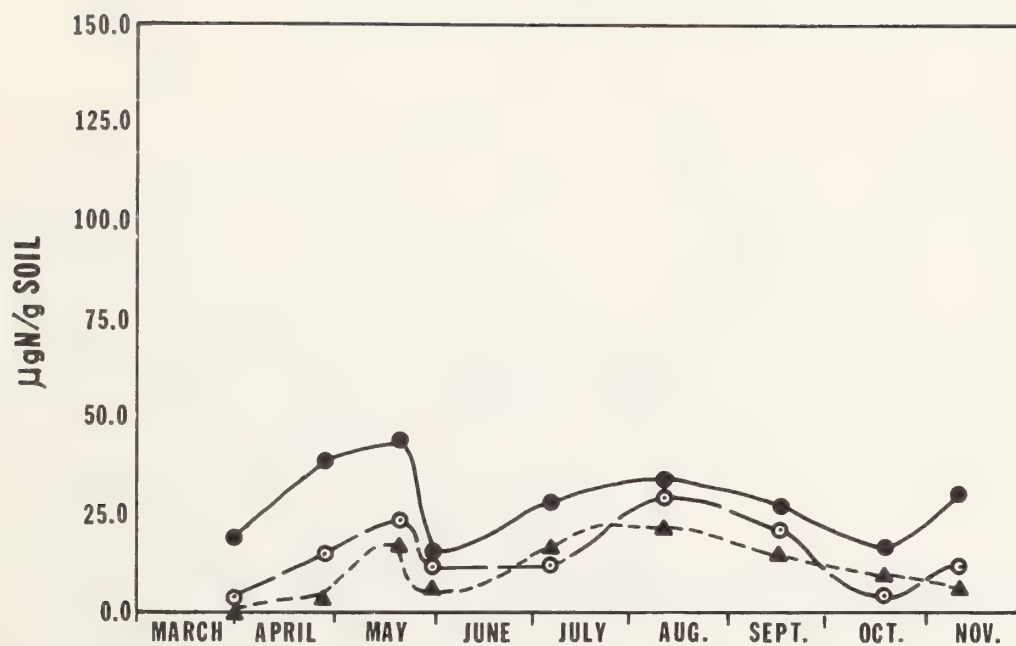
EXCHANGEABLE NH_4^+



FIXED AND EXCHANGEABLE AMMONIUM
IN THE SURFACE SOIL OF THREE SITES
FOR 1976 SAMPLING DATES

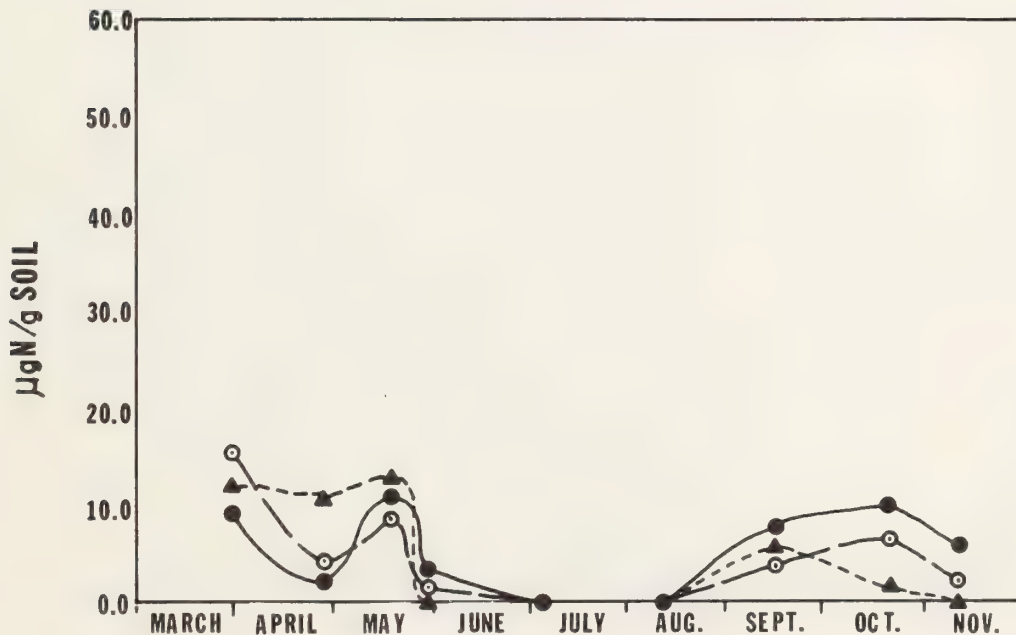


FIXED NH_4^+



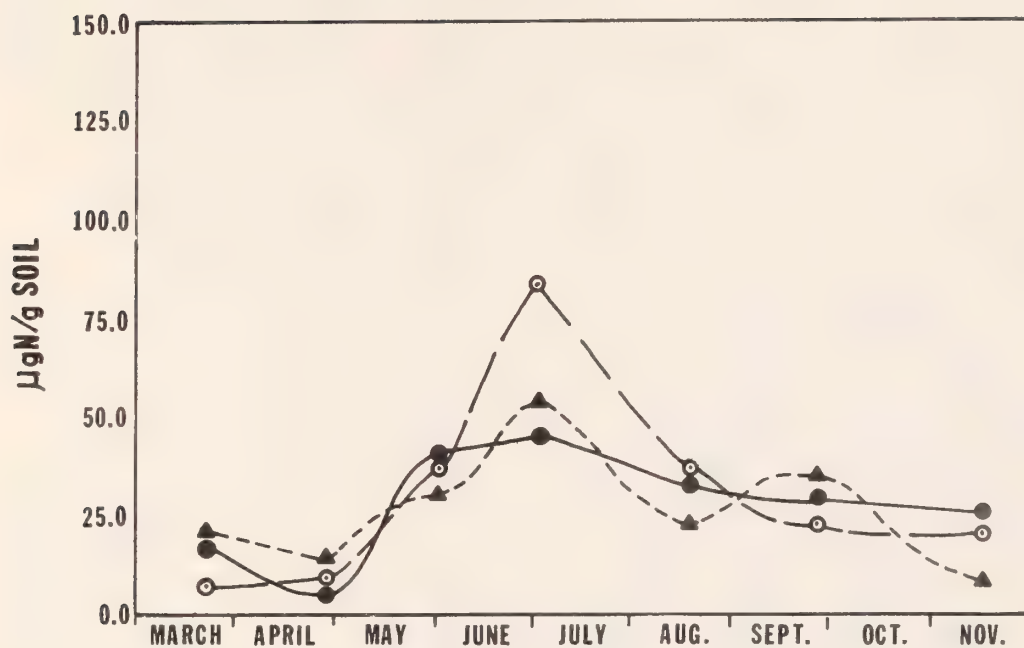
- SURFACE-3CM
- 5-20CM
- ▲ 40-50CM

EXCHANGEABLE NH_4^+



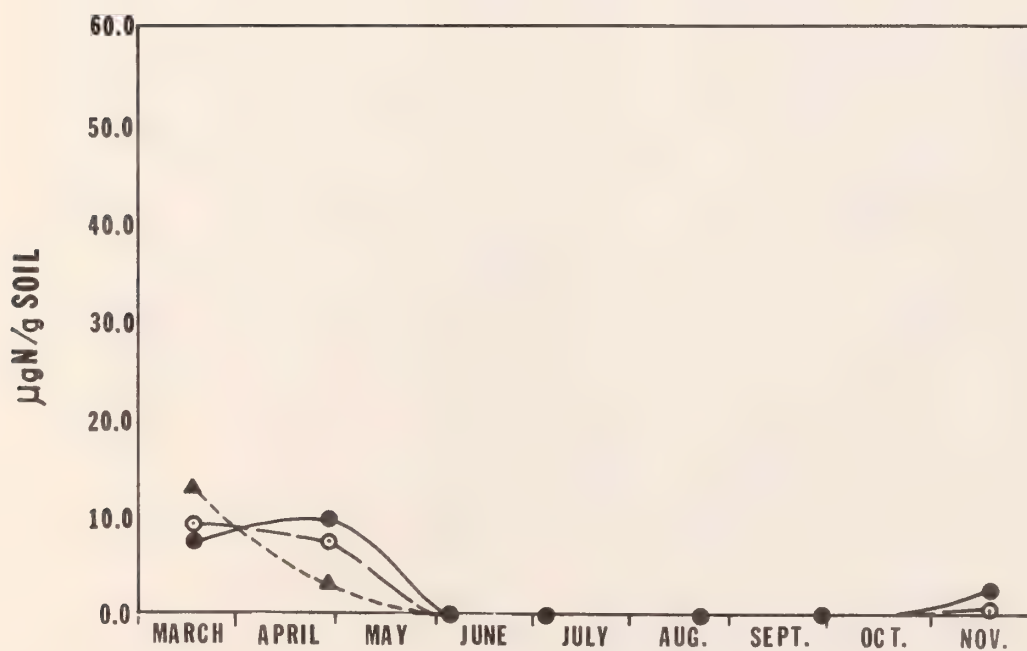
FIXED AND EXCHANGEABLE AMMONIUM
IN THREE DEPTHS AT SITE 39
FOR 1976 SAMPLING DATES

FIXED NH_4^+



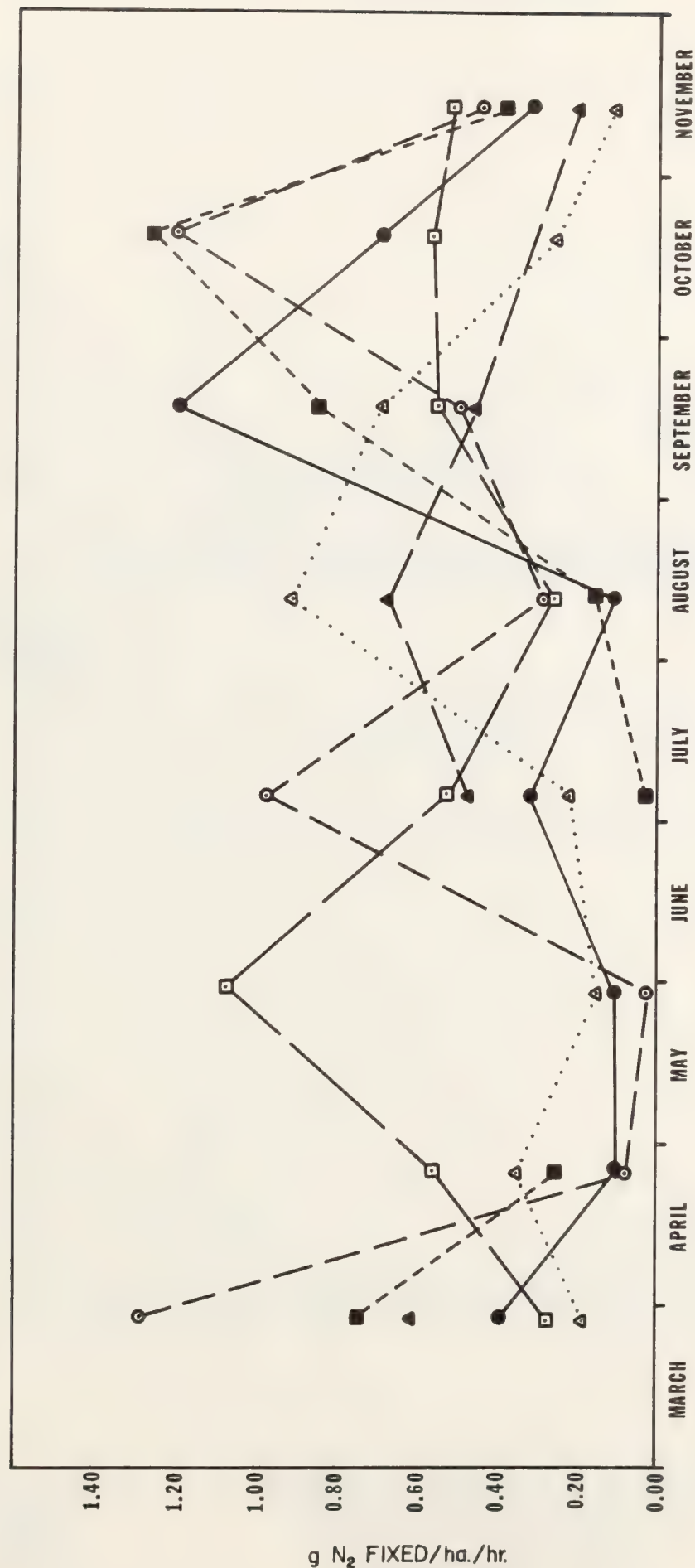
- SURFACE-3CM
- 5-20CM
- ▲ 40-50 CM

EXCHANGEABLE NH_4^+



FIXED AND EXCHANGEABLE AMMONIUM
IN THREE DEPTHS AT SITE 39
FOR 1975 SAMPLING DATES



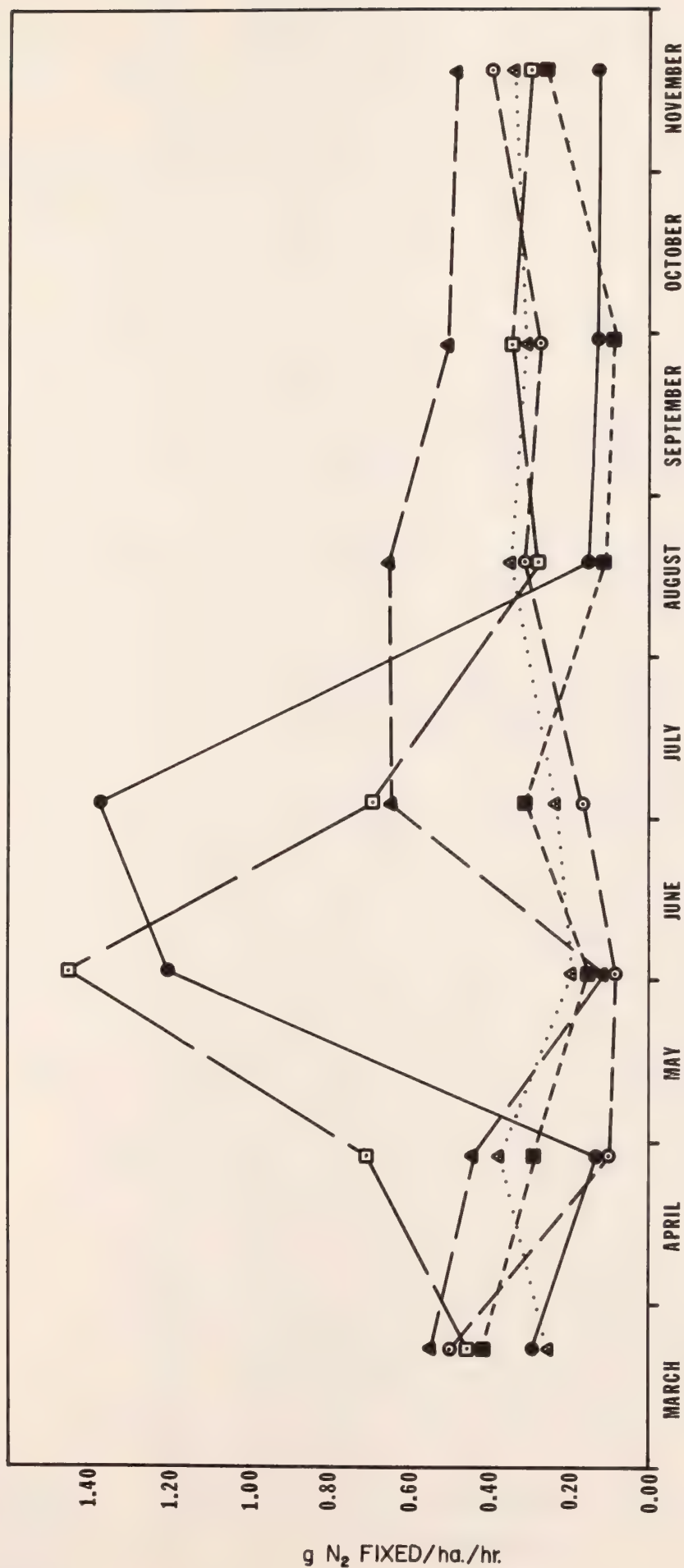


SITE

- — 39-1
- — 50JC-1
- — 50JE-1
- — 55R-1
- ▲ — 58C-1
- △ — 58I-1

NITROGEN FIXATION POTENTIAL FOR ALL SITES FOR 1975 SAMPLES



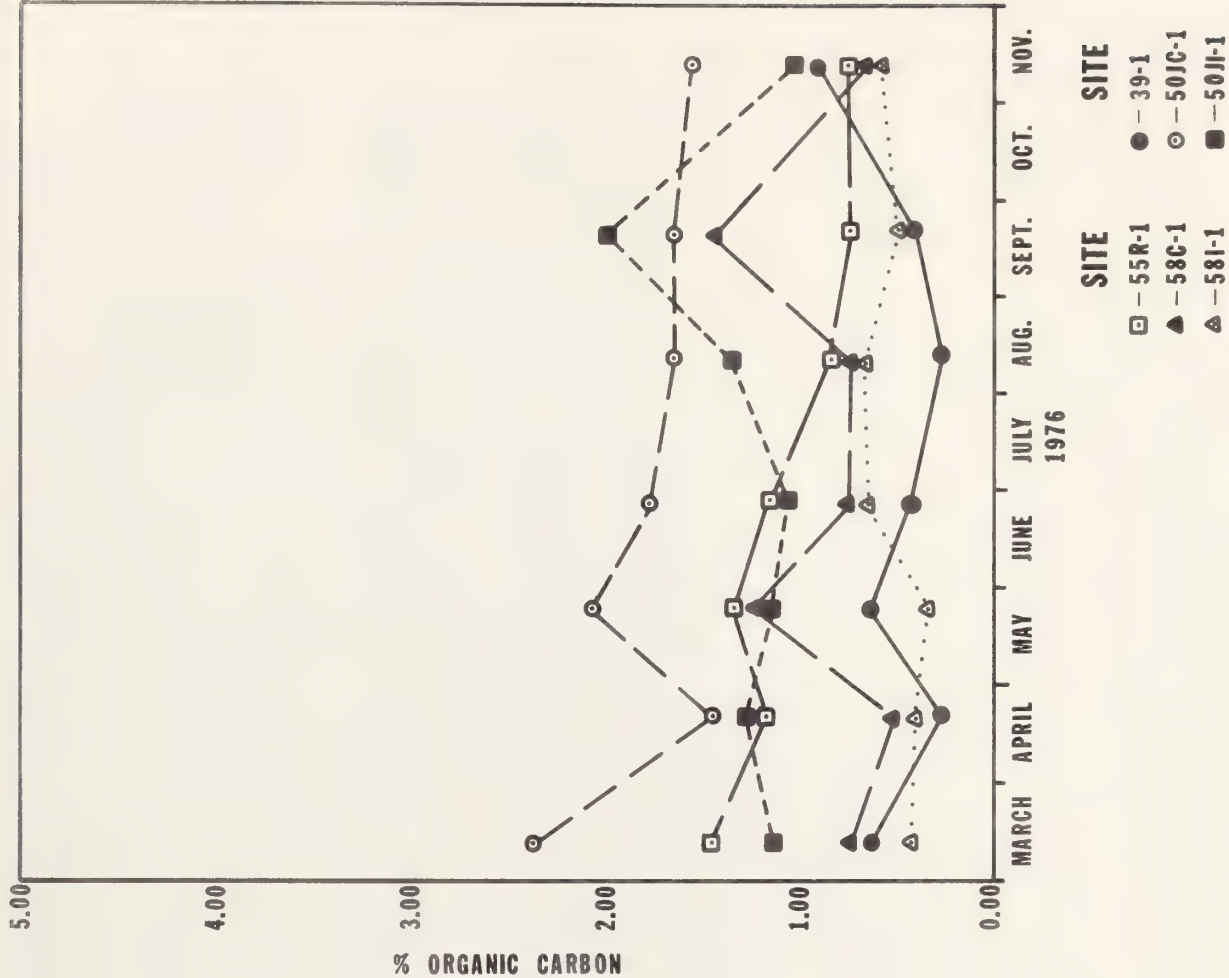
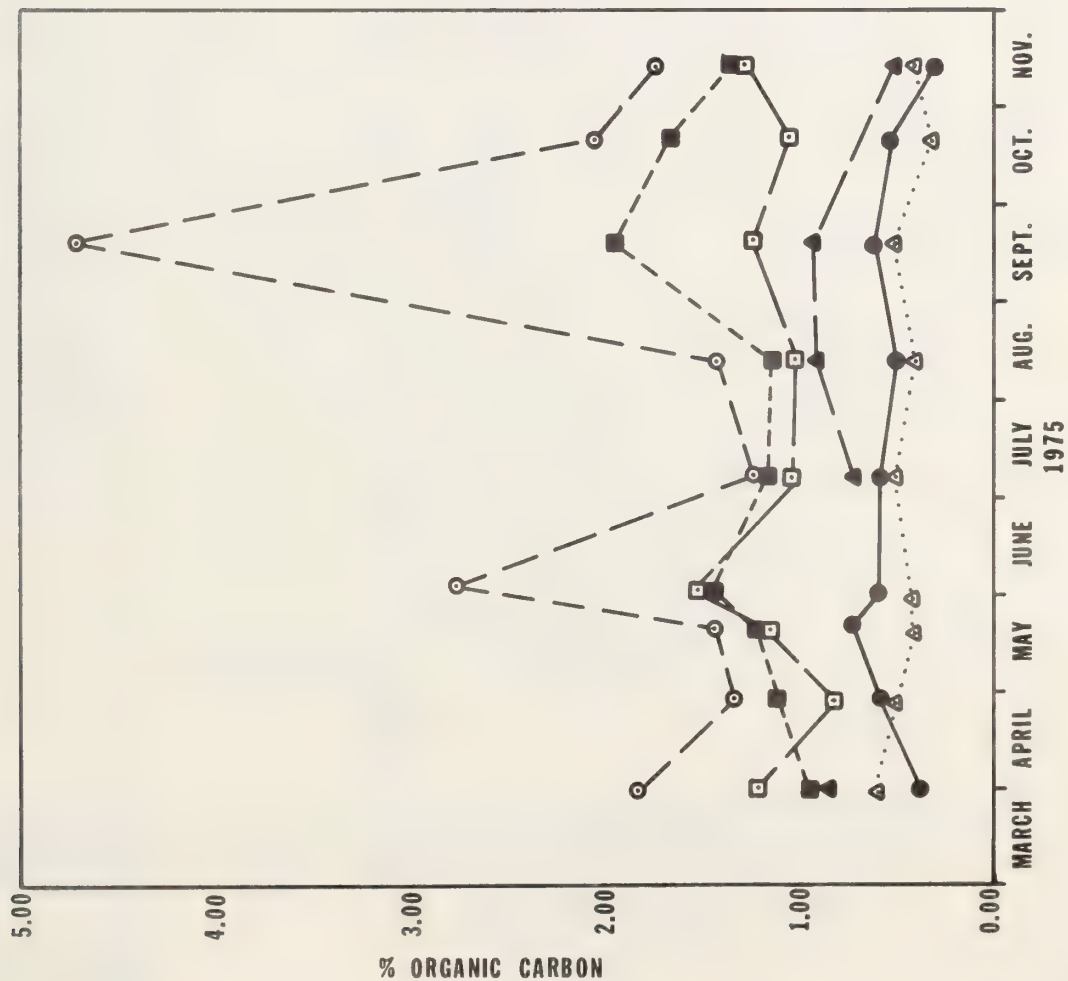


SITE

- — 39-1
- — 50JC-1
- — 50II-1
- — 55R-1
- ▲ — 58C-1
- △ — 58I-1

NITROGEN FIXATION POTENTIAL FOR ALL SITES FOR 1976 SAMPLES

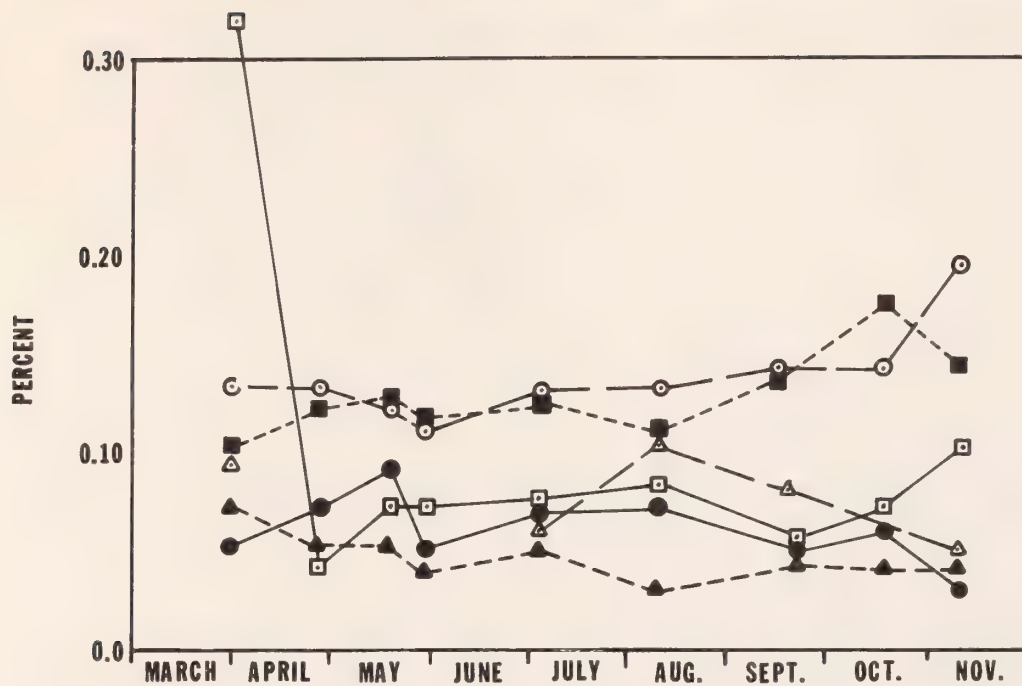




% ORGANIC CARBON IN THE SURFACE SOIL OF ALL SITES FOR 1975 AND 1976 SAMPLES



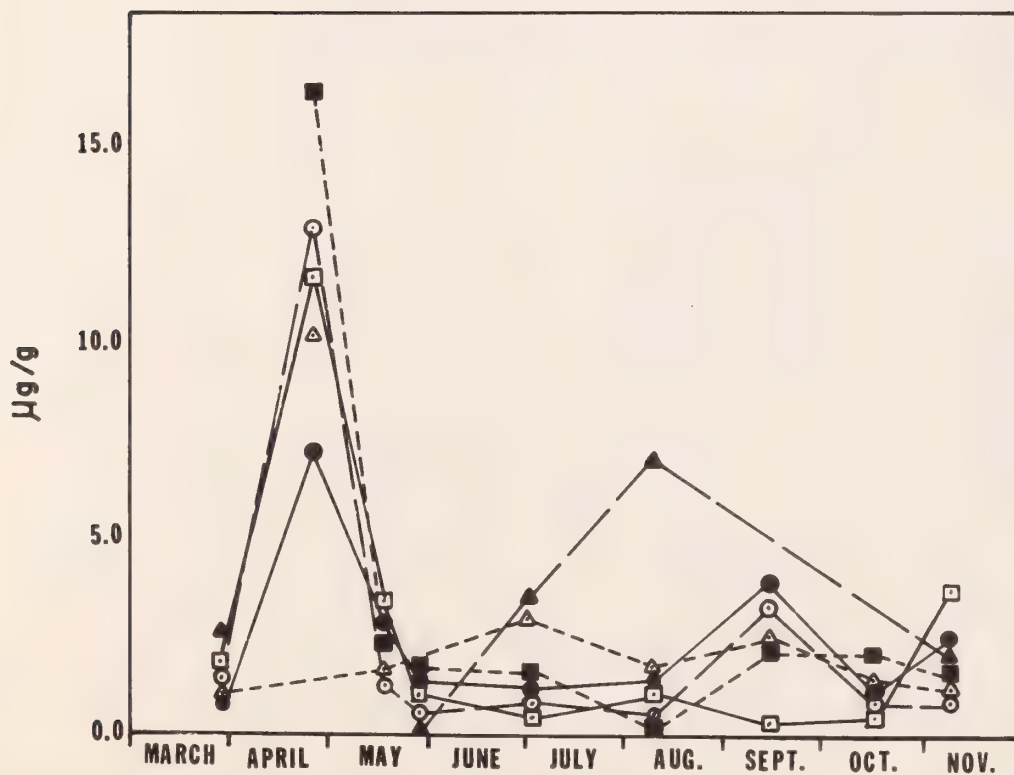
TOTAL NITROGEN



SITE

- 39-1
- 50JC-1
- 50JI-1
- 55R-1
- ▲ 58C-1
- △ 58I-1

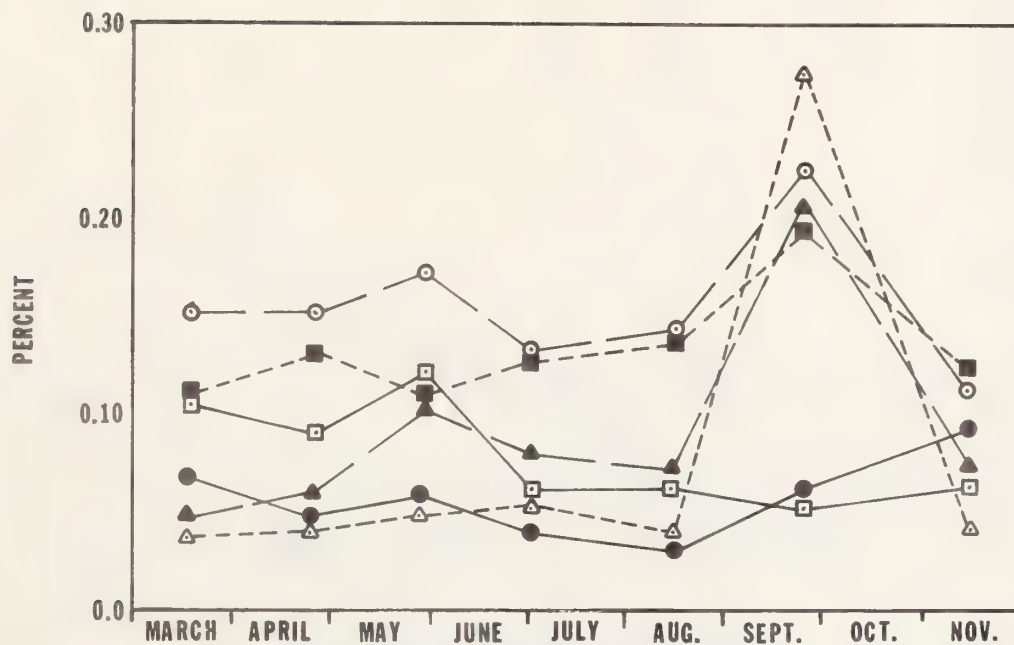
NITRATE (NO₃) NITROGEN



**TOTAL AND NITRATE NITROGEN IN THE SOIL AT ALL SITES
1975 SAMPLES**



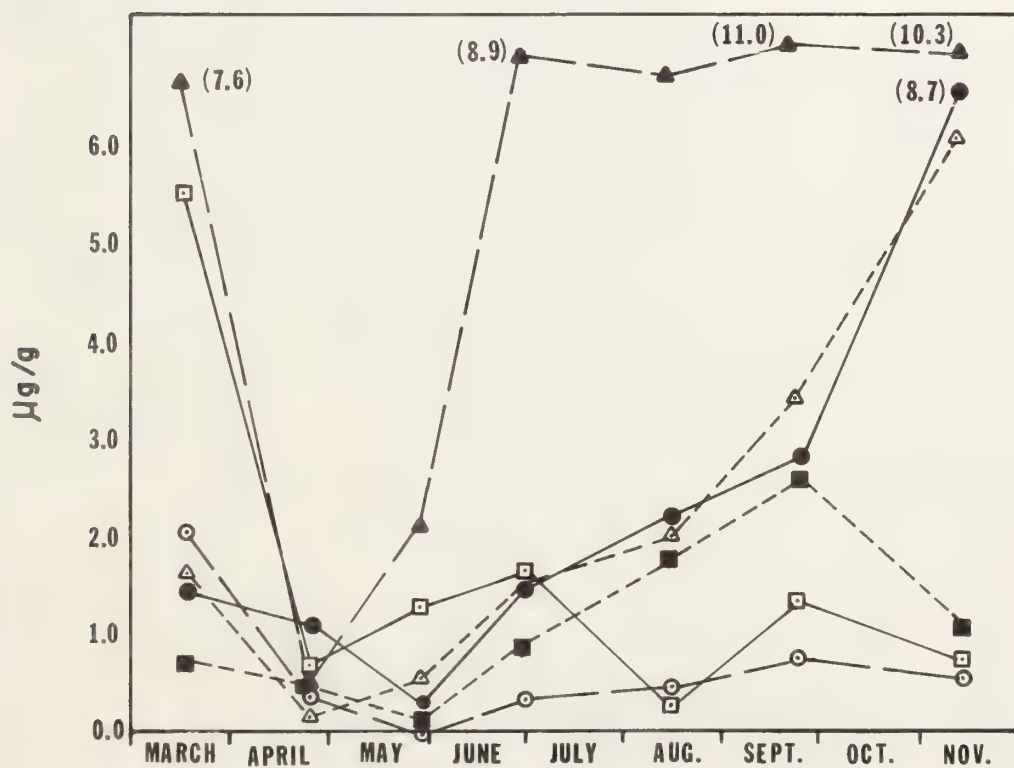
TOTAL NITROGEN



SITE

- 39-1
- 50JC-1
- 50JI-1
- 55R-1
- ▲ 58C-1
- △ 58I-1

NITRATE (NO₃) NITROGEN



TOTAL AND NITRATE NITROGEN IN THE SOIL AT ALL SITES 1976 SAMPLES



APPENDIX IV-79

C:N Ratios

1975

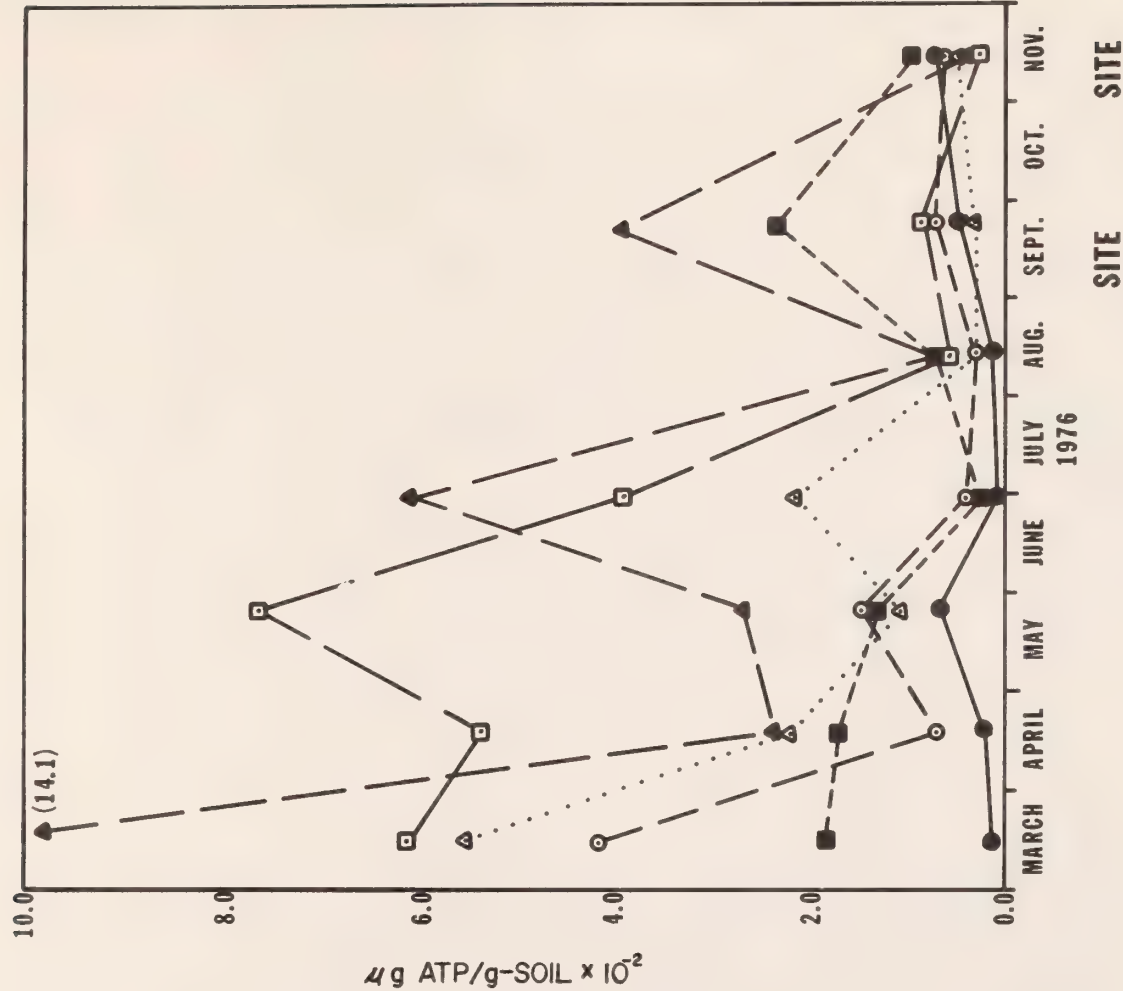
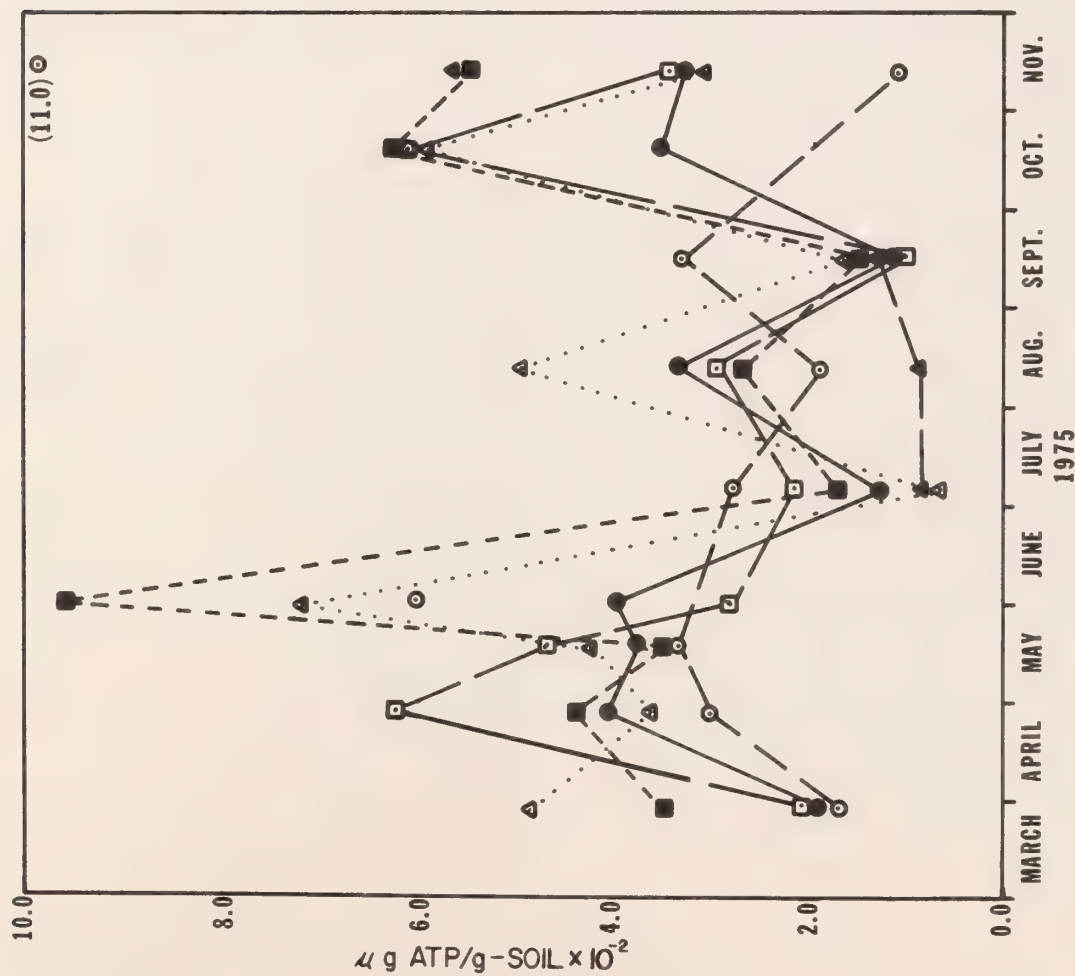
Sample	March	April	May	May	July	August	September	October	November
39-1	8.0	7.9	7.8	11.0	9.0	7.0	12.4	7.8	9.0
39-2	6.7	10.4	9.0	10.8	8.0	6.1	11.0	10.0	11.5
39-3	10.0	8.8	10.0	18.0	10.0	7.0	12.7	9.0	9.0
50JC-1	13.8	9.8	11.8	24.9	9.1	10.7	32.9	13.9	9.2
50JI-1	-	9.0	10.3	13.0	8.9	10.1	13.6	9.6	9.1
55R-1	-	21.0	16.9	20.0	14.9	12.6	24.2	14.4	12.8
55R-2	10.0	13.5	15.0	9.5	12.5	13.6	14.5	14.0	-
55R-3	23.3	15.0	23.0	26.0	16.3	14.6	12.3	10.8	14.0
58C-1	10.0	-	-	-	11.2	8.3	11.6	-	9.4
58C-2	10.0	-	-	-	11.2	11.6	14.4	-	7.3
58C-3	10.0	-	-	-	13.7	11.8	14.3	-	7.3
58I-1	8.6	10.8	8.6	9.0	10.4	13.6	10.6	6.8	9.5
58I-2	7.5	9.3	10.3	9.7	13.0	12.0	12.7	7.7	9.3
58I-3	10.0	12.0	6.6	5.5	11.0	11.6	11.7	8.7	11.0
50JC-L	18.9	-	-	-	-	-	53.2	-	51.3
58C-L	-	-	-	-	-	-	-	-	9.9

APPENDIX IV-80

C:N Ratios

1976

Sample	March 18	April 26	May 28	June 30	August 13	September 23	November 12
39-1	8.1	6.0	9.5	9.5	11.0	6.7	10.0
39-2	8.0	6.8	7.8	9.8	19.0	8.0	7.1
39-3	10.0	7.7	8.0	8.0	8.7	12.5	5.0
50JC-1	15.1	9.0	11.9	12.8	11.1	7.3	13.6
50JI-1	9.5	9.1	10.1	7.6	9.4	10.0	10.8
55R-1	13.0	13.1	11.0	16.3	12.5	14.0	15.0
55R-2	12.7	12.3	13.4	15.2	12.6	12.0	10.0
55R-3	14.0	10.8	15.8	13.3	9.7	15.0	13.3
58C-1	13.0	8.3	10.7	8.8	9.4	-	10.0
58C-2	10.5	10.3	9.9	9.5	10.8	-	10.0
58C-3	11.3	11.5	9.2	10.8	8.8	-	12.5
58I-1	9.5	7.4	6.8	10.0	18.5	-	15.0
58I-2	10.5	8.0	6.5	9.8	8.8	-	40.0
58I-3	10.7	9.3	10.3	8.3	12.7	-	10.0
50JC-L	45.0	-	-	25.2	11.1	-	8.1
58C-L	16.6	-	-	-	-	-	-



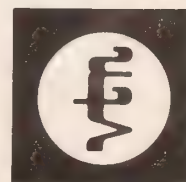
SITE

□ - 55R-1
▲ - 58C-1
△ - 58I-1

SITE

● - 39-1
○ - 50JC-1
■ - 50JI-1

ATP CONCENTRATIONS IN THE SURFACE SOIL AT ALL SITES FOR 1975 AND 1976 SAMPLING DATES



Nitrification Potential

(μg N/g soil)

1975

Sample	March 25		May 16		May 27	
	NH_4^+	$\text{NO}_2^- + \text{NO}_3^-$	NH_4^+	$\text{NO}_2^- + \text{NO}_3^-$	NH_4^+	$\text{NO}_2^- + \text{NO}_3^-$
39-1	142	9	29	23	80	0
50JC-1	6	31	0	25	52	14
50JI-1	0	21	0	0	0	28
55R-1	0	106	0	13	9	98
58C-1	-	-	-	-	-	-
58I-1	47	0	0	7	29	54

Sample	July 2		August 8		September 12		October 13	
	NH_4^+	$\text{NO}_2^- + \text{NO}_3^-$	NH_4^+	$\text{NO}_2^- + \text{NO}_3^-$	NH_4^+	$\text{NO}_2^- + \text{NO}_3^-$	NH_4^+	$\text{NO}_2^- + \text{NO}_3^-$
39-1	75	138	26	56	179	44	49	25
59JC-1	89	74	150	0	196	10	105	19
50JI-1	74	7	155	10	191	49	87	6
55R-1	2	138	19	19	131	0	1	41
58C-1	0	67	118	20	100	0	-	-
58I-1	96	6	71	4	65	0	32	23

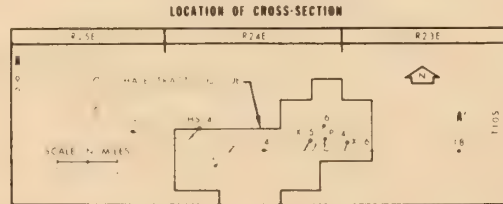
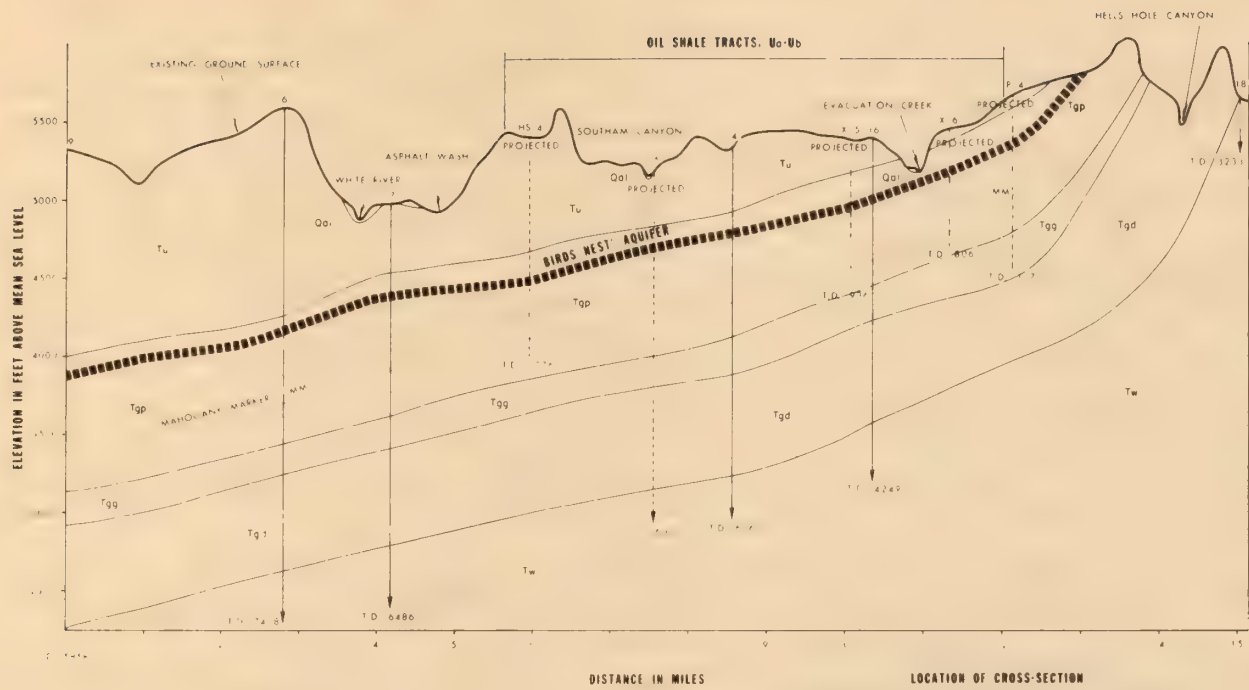
Sample	November 6	
	NH_4^+	$\text{NO}_2^- + \text{NO}_3^-$
39-1	0	169
50JC-1	0	4
50JI-1	0	33
55R-1	95	32
58C-1	116	1
58I-1	185	0

APPENDIX IV-83
NITRIFICATION POTENTIAL

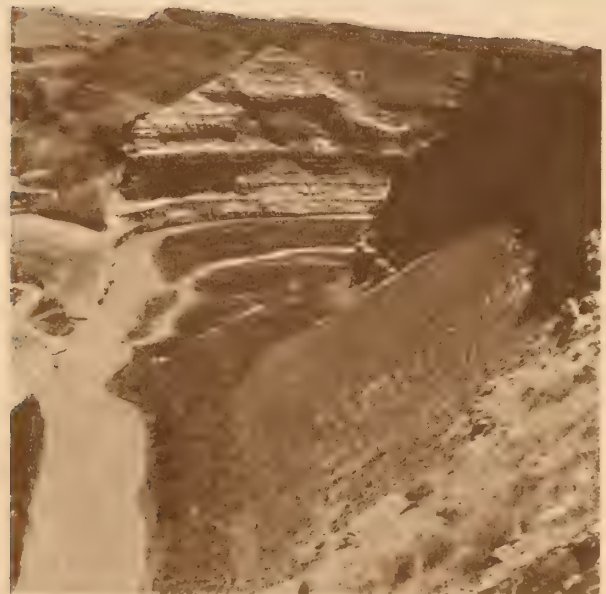
(µg N/g soil)

1976

Sample	APRIL 26		MAY 28		JUNE 30	
	NH ₄ ⁺	NO ₂ ⁻ + NO ₃ ⁻	NH ₄ ⁺	NO ₂ ⁻ + NO ₃ ⁻	NH ₄ ⁺	NO ₂ ⁻ + NO ₃ ⁻
39-1	155.4	11.2	92.5	0	68.5	114.2
50JC-1	8.7	30.1	63.0	12.1	43.2	8.6
50JI-1	0	27.4	0	30.7	51.7	16.1
55R-1	0	107.8	9.1	106.8	0	128.6
58C-1	53.2	0	33.2	58.2	74.7	15.3
58I-1	29.3	6.1	17.6	36.0	0	61.0
	AUGUST 13		SEPTEMBER 23		NOVEMBER 12	
	NH ₄ ⁺	NO ₂ ⁻ + NO ₃ ⁻	NH ₄ ⁺	NO ₂ ⁻ + NO ₃ ⁻	NH ₄ ⁺	NO ₂ ⁻ + NO ₃ ⁻
39-1	3.8	40.5	11	166	0	75.4
50JC-1	168.4	0	186	56	63.1	0
50JI-1	168.6	24.6	154	17	92.9	0
55R-1	23.7	14.0	0	141	72.3	26.0
58C-1	121.0	22.3	41	7	112.5	0
58I-1	64.3	6.5	41	10	-	-



V SOILS & GEOLOGY



V. SOILS AND GEOLOGY

The purpose of the soils and geology program was to document soils and geological conditions on the tracts and the 1.6-km (1-mi) boundary. The investigation included an in-depth study of soils types and productivity and of site and regional geology, physiography, stratigraphy, structure, and seismicity.

A. SOILS

1. METHODOLOGY

The soils were surveyed according to the standard procedures of the Soil Conservation Service (SCS) and the Utah Agricultural Experiment Station, Department of Soils and Biometeorology. Prior to the study, a reconnaissance was conducted by stereoscopic study of aerial photographs and by on-site observations. Geologic maps of the area were studied to determine general relationships of parent materials to the soil types. The vegetation and relief were studied to determine their relationship to the soils. Selected areas were then excavated to expose the soil layers, or horizons, which generally extend from the surface down into the parent material. The sequences of these natural layers are described in detail in the First Year Environmental Baseline Report (FYEBR) according to the methods and nomenclature of the Soil Conservation Service (U.S. Department of Agriculture 1951).

During the survey, soil samples were collected at selected locations from each horizon for processing at the soil laboratory at Utah State University (USU). Comparisons of field data and analytical data from the laboratory were used to name the soil types.

2. SUMMARY OF RESULTS

a. Soil Survey

The soil survey identified 24 soil-map units, which were mapped according to their location on the tracts (Figure V-1). Each map unit represents one soil type or complexes of two or more soils so intermingled or small in extent that they could not be shown separately. Each soil complex contains at least 75% of the two or more dominant soils,

and the distribution and relative proportions are about the same in all units. The name of a soil complex consists of the names of the dominant soils joined by a hyphen. Because rock outcrop and bare rock surfaces are extensive in the area, some of the map units are complexes of soils and rock outcrop.

Most of the map units are composed of one of nine different soils identified as -- A, As, B, Bs, Ds, E, F, N, and W. Each type is described in detail in the FYEBR. Notations concerning soil texture, thickness, underlying parent material, occurrence, elevation, vegetation, precipitation, and temperature are included in each description; also included for each type is a description of a representative pedon, a block of soil considered typical of the soil type.

b. Soil Formation

Soil characteristics are determined by the interaction of five principal soil factors: (1) parent material; (2) climate; (3) topography; (4) biota (plants, animals and man); and (5) time.

The soils along the flood plain of the White River and along smaller drainageways throughout the area have formed in alluvium. The alluvium along the White River has come from a wide range of transported materials, whereas in the smaller drainages the materials are largely deep sandy loams and channery sandy loams derived locally from the Uinta and Green River formations. The parent material for the upland soils is also the Uinta and Green River Formations, over which the soils are shallow or very shallow.

Two important climatic factors in the formation of soils on the tracts are precipitation and temperature. In Vernal Utah, the average yearly precipitation is about 20 cm (8 in.) and the average precipitation is about 1.5 cm (0.6 in.) per month from October through March and from June through July, and about 2.0 cm (0.8 in.) per month during April, May, September, and October. On the tracts the average annual soil temperature at 51 cm (20 in.) is estimated to be slightly less than 8°C (47°F); the soils are therefore in the frigid soil family.

The tracts are in the Colorado Plateau physiographic province, distinguished by the nearly level bedrock and the numerous canyons and generally high elevation. Most of the area is between 1520 m and 1850 m (5000 ft and 6000 ft) above sea level. The topography of the area is sloping to steep slopes ranging from about 5% to over 60%. The western part of the survey area is characterized by numerous nearly vertical

LEGEND

A(1-5) - SHALLOW CHANNERY LOAMS, 3 TO 40 PERCENT SLOPES

As(1-5) - SHALLOW CHANNERY SANDY LOAMS, 5 TO 60 PERCENT SLOPES

B(1-3) - SHALLOW CHANNERY AND FLAGGY LOAMS, 5 TO 40 PERCENT SLOPES

Bs(1-6)(R) - SHALLOW CHANNERY AND FLAGGY SANDY LOAMS, 10 TO 60 PERCENT SLOPES

Ds(D) - SANDY LOAMS, 5 TO 10 PERCENT SLOPES

E (EN) - DEEP LOAMS, 5 TO 10 PERCENT SLOPES

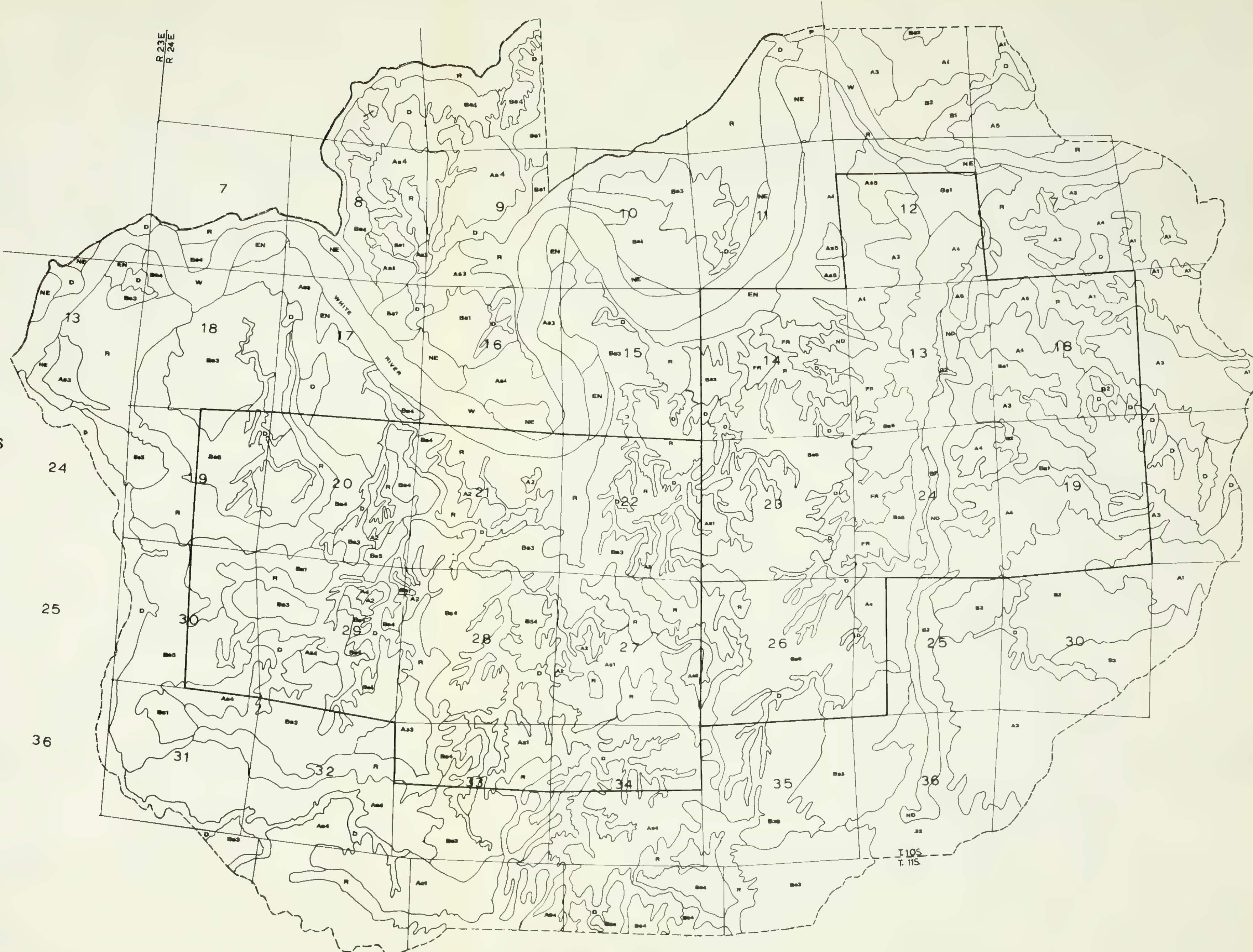
F (FR) - SHALLOW LOAMY SANDS, 3 TO 7 PERCENT SLOPES

N(NE, BD) - DEEP, MODERATELY FINE TEXTURED SOIL, 5 TO 10 PERCENT SLOPES

W - DEEP SILTY ALLUVIUM, 0 TO 2 PERCENT SLOPES



PHOTO MOSAIC; NOT TO SCALE



SOILS MAP
OIL SHALE TRACTS Ua, Ub AND CORRIDOR
NOVEMBER 1975



sandstone cliffs. The eastern part of the area, east of Evacuation Creek, has more rolling topography and fewer sandstone cliffs.

Shrubs, forbs, and grasses are the dominant vegetation over much of the area. Juniper trees are common at higher elevations above 1650 m (5400 ft) west of Evacuation Creek, with scattered pinyon pine at the highest elevations. There is an open stand of large cottonwood trees along the White River valley, and young willows and tamarisk grow in the most recent deposits. Big sagebrush is the dominant vegetation along numerous drainageways throughout the area. Shadscale, black sage, cheatgrass, Indian ricegrass, squirreltail, and some forbs are common on shallow upland soils. Greasewood and shadscale are common in alkali-affected areas.

Burrowing animals are important in mixing the various soil materials, and the mounds and disturbed areas are conspicuous in the survey area. Grazing animals affect soils by removing vegetation, which tends to increase erosion. Man has affected soil development in the area by building roads and trails, which also contribute to erosion.

Time is essential in soil formation, whether it be a few years or centuries. For instance, entisols such as Typic Torrifluvents along the major and minor drainageways are young soils that have not been in place and undisturbed long enough for distinct horizons to develop. Typic Natrargids are examples of soils with well-differentiated horizons. These soils occur on higher terraces, which implies greater age, or more time for soil-forming processes to act.

c. Soil Classification

The nine different soil types found on the tracts have been classified into two soil orders (soils with similar sets of soil-forming processes): Entisols, soils that lack distinct horizons, and Aridisols, soils that are generally dry with light-colored or thin surface horizons and well-expressed lime horizons (calcic horizon) or sodic horizons (natic horizon). The soil classifications are shown on Table V-1.

Soil orders are divided into suborders, primarily on the basis of closest genetic similarity. The suborders in the survey area, identified by the last two syllables of the subgroup (Table V-1), are orthids, orthents, fluvents, and argids. The basis for this division is differences resulting from climate or vegetation, or the presence or absence of waterlogging.

TABLE V-1

SOIL CLASSIFICATION

<u>Soil</u>	<u>Family</u>	<u>Subgroup</u>	<u>Order</u>
A	Loamy-skeletal, mixed, frigid	Lithic Calciorthid	Aridisols
As	Loamy-skeletal, mixed, frigid	Lithic Calciorthid	Aridisols
B	Loamy-skeletal, mixed (calcareous) frigid	Lithic Torriorthent	Entisol
Bs	Loam-skeletal, mixed (calcareous) frigid	Lithic Torriorthent	Entisol
Ds	Coarse-loamy, mixed (calcareous) frigid	Typic Torrifluvent	Entisol
E	Coarse-loamy, mixed, frigid	Typic Calciorthid	Aridisol
F	Coarse-loamy, mixed (calcareous) frigid	Lithic Torriorthent	Entisol
N	Fine, mixed frigid	Typic Natrargid	Aridisol
W	Fine, mixed (calcareous) frigid	Aquic Ustifluvent	Entisol

Suborders are divided into great groups. An example of a great group name is Calciorthid, the name for aridisols with a strong calcic horizon. Great groups are based on the uniformity in the kinds and sequence of major soil horizons and properties. The horizons used to make separations are those in which clay, iron, humus, or lime have accumulated, or those that have layers that interfere with root growth or water movement. Properties used also include soil temperature and major differences in chemical composition.

Great groups are divided into subgroups. There is a central (typic) concept of the group and there are intergrades that have slightly different properties. For instance, Lithic Calciorthids are a subgroup that indicates a shallow soil less than 51 cm (20 in.) to bedrock with a strong calcic horizon.

Families are based on the properties important to the growth of plants or to engineering. Among the properties considered are texture, mineralogy, reaction, and soil temperature. Coarse-loamy, for example, indicates a sandy-loam texture, and mixed indicates that the clay mineralogy is varied. Frigid indicates that the mean annual soil temperature at 51 cm (20 in.) deep is less than 8°C (47°F). The soils were not classified into soil series because of the limited size of the survey area.

d. Laboratory Analysis of Soils

Soils were sampled by horizon from selected locations and analyzed by the USU Cooperative Soils Laboratory (U.S. Department of Agriculture 1967). The samples were analyzed for the physical and chemical properties that are used as a basis for characterizing and classifying soils. The laboratory data sheets are appendicized in the FYEBR. Table V-2 lists selected data for the different soils, including soil type; depth sampled; particle-size distribution; texture; reaction, or pH; organic carbon; electrical conductivity; percent calcium carbonate equivalent; extractable cations (Mg, Na and K); available P; and percent moisture at saturation.

As shown on Table V-2, the textural class of the soils sampled varies from silty loams, sandy loams, clay loams, and loams. The pH varies from about 7.8 to 8.9, not especially high for soils high in calcium carbonate. Extractable sodium is generally moderate, except in N soils, which have 11 to 20 milliequivalents of Na per 100 g of soil. In other upland soils the extractable sodium is highly variable and occasionally increases in horizons near bedrock.

TABLE V-2

LABORATORY ANALYSIS OF SELECTED SOILS

Size Class and Diameter of Particles

Soil Name & Collec. No.	Depth From Surface (cm)	%Very Coarse Sand 2-1 mm	%Coarse Sand (1-0.5 mm)	%Medium Sand (.25mm)	%Fine Sand (.10mm)	%Very Fine Sand (0.05mm)	%Silt (0.05-.002 mm)	%Clay <0.002 mm	% Sand >2mm	Text-ural Class*	pH Satur. Paste	Organ. Carbon	Elect/Conduct mmhos/cm	CaCo3 Equiv. %	Extract. Cations NH4OAc Me/100g.			Avail. P ppm	% Moist. Satur.
															Mg	Na	K		
A #68	0-8	7	4	4	15	18	38	14	48	L	8.1	1.5	.5	2.9	1.0	.5	.4	7.5	32
	8-20	10	6	4	13	12	40	20	40	L	8.1	1.4	.6	8.4	1.1	1.1	.2	2.0	47
	20-33	22	11	5	8	7	35	17	48	L	8.6	1.0	.8	9.8	.6	4.6	.1	1.1	44
	33-50	17	10	6	13	10	26	17	47	L	8.7	0.9	1.2	5.3	.6	10.4	.2	2.8	48
As #67	0-5	10	9	12	19	9	27	14	59	SL	8.0	1.4	.5	7.0	.4	.4	.3	6.9	38
	5-12	13	8	8	20	15	28	15	58	SL	8.2	1.5	.6	8.6	1.0	1.3	.1	1.6	52
	12-25	14	9	7	16	12	34	14	52	SL	8.7	1.2	1.0	10.7	1.6	7.2	.1	1.1	51
	25-35	18	12	8	20	11	32	13	65	SL	8.9	0.6	1.8	7.9	1.6	8.4	.1	.8	40
B & Bs #63	0-8	9	8	7	17	11	38	20	42	L	8.0	.5	.7	7.2	1.5	.9	.2	4.9	28
	8-14	7	4	3	7	8	55	21	24	SiI	7.5	.7	1.7	11.4	3.3	5.8	.2	2.1	42
	14-27	6	3	1	5	11	60	25	15	SiI	8.3	.5	2.5	14.2	3.5	10.9	.2	.5	44
	0-10	9	9	11	21	11	27	11	62	SL	8.1	1.1	.6	5.8	1.1	.3	.3	17.0	32
Ds #64	10-40	14	14	14	23	9	19	11	70	SL	8.1	.5	.4	5.9	.9	.5	.1	3.6	30
	40-65	12	14	13	20	9	23	12	65	SL	8.1	.4	.6	9.2	.5	.8	.1	3.7	31
	65-113	11	16	15	21	9	21	11	68	SL	8.1	.4	2.6	7.5	.9	3.8	.1	4.1	33
	113-150	12	12	13	22	11	23	10	67	SL	8.1	.3	28.0	7.2	.5	12.9	.2	2.4	29
E #76	0-10	2	2	3	15	32	31	8	61	SL	8.2	.6	.5	5.2	1.5	.3	.5	7.9	31
	10-23	1	1	2	9	23	41	16	43	L	8.2	.5	.7	12.5	2.6	.6	.2	1.3	33
	23-47	1	1	1	6	24	45	23	32	L	8.4	.4	.7	18.7	3.3	1.7	.2	.8	37
	47-75	3	3	6	20	17	33	19	48	L	8.6	.3	.9	11.9	2.4	3.5	.2	.7	31
F #39	75-120	4	6	8	22	14	29	14	57	SL	8.1	.4	4.2	9.4	1.7	5.2	.1	1.0	34
	120-150	8	8	9	22	13	25	14	61	SL	8.0	.4	18.0	7.8	1.7	10.1	.2	1.4	30
	0-4	2	11	30	29	8	9	8	83	LS	8.1	.5	.6	3.0	1.0	.3	.4	16.0	29
	4-17	6	13	30	25	6	11	11	78	SL	8.2	.5	.5	3.7	1.3	.5	.2	3.2	32
N #48	17-35	11	19	27	21	5	8	10	72	LS	8.5	.5	.3	6.8	1.0	.5	<.1	1.0	38
	0-9	1	1	3	16	33	33	10	37	SL	8.7	.3	.9	4.5	2.4	1.7	.9	6.4	28
	9-20	<1	1	2	12	26	34	27	39	L	8.9	.3	2.4	10.5	3.9	11.4	.3	3.4	48
	20-34	<1	1	2	8	15	35	38	27	CL	8.5	.3	14.0	15.2	5.7	19.8	.2	1.8	62
W #75	34-55	<1	1	3	12	16	35	31	34	CL	8.2	.2	33.0	15.5	5.7	19.6	.2	1.0	48
	55-89	<1	1	2	7	21	40	30	30	CL	8.1	.2	22.0	15.4	5.0	15.7	.1	1.0	48
	89-158	1	2	2	8	17	46	26	28	L	8.3	.1	20.0	11.7	5.0	13.5	.2	.6	49
	0-10	7	1	1	1	2	62	23	15	SiI	8.2	5.1	1.4	11.3	5.5	1.3	2.7	27.0	67
	10-20	<1	1	1	5	9	60	17	34	SiI	8.2	1.1	.1.5	11.0	4.0	1.6	1.7	2.1	47
	20-30	1	1	1	1	2	59	38	4	SiCL	8.0	1.2	14.0	12.0	8.9	7.8	1.5	2.0	65
	30-65	<1	<1	1	1	2	64	34	3	SiCL	8.1	1.0	24.0	11.4	11.5	13.3	.7	2.0	60
	65-90	<1	<1	1	40	31	17	8	75	SL	8.2	.3	16.0	6.0	4.5	4.6	.2	1.2	33
	90-130	<1	<1	<1	29	37	23	8	69	SL	8.3	.5	16.0	7.1	5.8	5.7	.1	.7	34
	130-195	1	1	<1	2	4	68	17	15	SiI	8.1	.8	28.0	12.3	10.0	13.3	.3	.7	51

NOTE: *L-loam, loamy C-clay S-sand, sandy Si-silt, silty

The organic carbon content of the surface soils varies from 0.5% to 2.6% and generally decreases with depth, which is typical for soils in this setting. The exception is soil W, which has 5% organic carbon in the surface layer.

Electrical conductivity, or salinity, is generally low, especially in the upper 40 cm (16 in.). The exception is soil N with electrical conductivity values ranging from less than 3 mmhos/cm at 20 cm (8 in.) to 33 mmhos/cm at 34 cm (13 in.). Conductivity in soil W varies from less than 2 mmhos/cm in the surface to 28 mmhos/cm at 130 cm (51 in.).

The calcium carbonate equivalent varies from about 3% to 30% in surface layers and 5% to 50% in the subsoils. The values are typical for soil formed from calcareous rocks in areas with less than 15 cm to 23 cm (6 in. to 9 in.) of annual precipitation.

The values of extractable cations are typical for soils formed from saline calcareous sandstone with these climatic conditions. The amount of available phosphorus is highly variable. It is concentrated in the surface soil and decreases markedly with increasing depth. The percent moisture at saturation is the percentage by weight of water the soil can hold. The moisture-holding capacity depends on texture, organic matter, structure, and other factors.

Table V-3 shows the results of 15 soil samples analyzed by X-ray to determine the type of clay minerals present. Clay mineralogy is the basis for classifying the soil at the family level. Boron at selected depths of five soils, shown on Table V-4, ranges from 0.2 ppm to 1.4 ppm. According to Richards (1951):

Permissible limits for boron in the saturation extent of soils can at present be given only on a tentative basis. Concentrations below 0.7 ppm boron probably are safe for sensitive plants; from 0.7 to 1.5 ppm boron is marginal; and more than 1.5 ppm boron appears to be unsafe. The more tolerant plants can withstand higher concentrations, but limits cannot be set on the basis of present information.

e. Use and Management of Soils

Managed by the BLM, the area is used mainly as winter range for sheep, and some cattle use the bottomlands along the White River for summer range. Mule deer are the principal game species that use the range.

TABLE V-3

RESULTS OF X-RAY ANALYSIS OF 15 SOIL SAMPLES
FROM OIL SHALE TRACTS U-a AND U-b

Soil	Sample #	Depth from Surface (cm)	Quartz	Calcite	Dolomite	Feldspar	Illite	Kaolinite	Montmorillonite
Ds	22	25-36	X	X	?	X	X-1	X-1	X-1
A	37	8-22	X	X		?	X-5	X-5	X-1
A	38	27-53	X	X		X	X-5		X-1
A	39	17-35	X	X		X		X-5	X-1
Bs	40	31-137	X	X		X		X-5	X-1
Bs	42	41-60	X	X	X		?		X-1
E	45	40-76	X	X					X-1
E	46	20-45	X	X		X	X-4	X-5	X-1
A	48	55-89	X	X		X	X-2	X-3	X-1
A	50	11-30	X	X		X			X-1
As	53	23-45	X	X					X-1
As	54	17-30	X	X				X-5	X-1
Ds	55	40-120	X	X			X-1		?
Ds	58	34-72	X	X		X	X-5	X-5	X-1
Ds	63	14-27	X	X	?	X	X-5	X-5	X-1

X means the mineral appears in the less than 2 μ fraction. The clay minerals are ranked in order of abundance, with 1 being most abundant and 5 least abundant. Abundances are only estimates.

TABLE V-4

RESULTS OF THE BORON TESTS ON SOIL SAMPLES FROM
TRACTS U-a AND U-b

<u>Soil</u>	<u>Pedon #</u>	<u>Depth (cm)</u>	<u>Boron (ppm)</u>
Ds	#64	10-40	0.3
	#63	113-150	0.4
W	#75	30-65	0.4
	#75	130-195	0.2
E	#76	120-150	0.5
Ds	#45	40-76	1.4
	#45	76-121	0.9
N	#48	20-34	1.3
	#48	34-55	1.0

Table V-5 gives the estimated herbage yields for favorable and unfavorable years and for the various capability classes for the nine soils. The capability classes indicate the suitability of the soils for most kinds of crops. The classes are designated I through VIII. (The numerals indicate progressively greater limitations and narrower choices for practical use.) The nine soils in the area were placed in two capability classes, VI and VII. Class VI soils have severe limitations that generally make them unsuited to cultivation and limit their use largely to pasture or range, woodland or wildlife. Class VII soils have very severe limitations that make them unsuited to cultivation and restrict their use largely to range, woodland, or wildlife. The "e" shows that the main limitation is the risk of erosion; the "w" indicates that the soil is wet.

f. Engineering Uses of the Soils

For any engineering use, it is important to consider certain physical characteristics of a soil, including permeability, strength, compaction characteristics, drainage, shrink-swell potential, grain size, plasticity, and reaction. Also important are slope, depth to bedrock, and depth to water table.

Table V-6 (U.S. Department of Agriculture 1971) gives the estimated and measured properties of soils on the site, including slope, depth to bedrock, texture class, Unified system and AASHTO classification, liquid limit, plastic limit, permeability, available water capacity, pH, electrical conductivity, shrink-swell potential, and hydrologic soil group. Table V-6 is explained in more detail in the FYEBR.

Table V-7 gives the interpreted engineering properties of soils at the site. Interpretations are based on test data and field experience with soils in the area and similar soils in other areas. It should be emphasized that the interpretations made in this survey are not a substitute for on-site sampling and testing needed at a site chosen for specific engineering work that involves heavy loads, or a site where excavations are deeper than the depths of the layers here reported.

The soils were rated on the degree and kind of limitation affecting their use as septic tank absorption fields, sewage lagoons, sanitary landfill, dwellings with and without basements, and local roads and streets. The ratings are as follows:

"Slight" means that the soil has a few limitations that are easily overcome.

TABLE V-5

ESTIMATED HERBAGE* YIELDS IN KG/HA AND
LAND USE CAPABILITY CLASSES OF SOILS

Soil	<u>Yields</u>		Capability Classes
	Favorable yrs. Kg/ha	Unfavorable yrs. Kg/ha	
A	800	400	VIe
B	400	200	VIIe
As	1000	600	VIIe
Bs	450	250	VIIe
D	1250	900	VIe
E	1250	900	VIe
F	400	200	VIIe
N	150	100	VIIe
W	3500	2000	VIw

*Total yield of above-ground plant parts (SCS standard methodology)

Conversion from kg/ha to lb./ac is made by multiplying kg/ha values by 0.9.

TABLE V-6

ESTIMATED AND MEASURED SOIL PROPERTIES SIGNIFICANT TO ENGINEERING REQUIREMENTS¹

Soil	Slope Range (%)	Depth to Bedrock (cm)	Texture Class	Unified	AASHO	Liquid Limit	Plastic Limit	Permeability (In/Hr)	In/In Available Water Capacity	pH	ECe mmhos/cm	Shrink-Swell Potential	Hydrologic Soil Groups
A	3 to 40	30 to 50	channery loam	SM GC	A-2-4	24-33	NP-0	1.0-2.5	0.09-0.11	7.5-8.7	0.4-5.4	Low	C (moderately high runoff potential)
As	5 to 60	30 to 50	channery sandy loams	SM GM	A-2-4	24-36	NP	1.5-3.0	*0.1	8.1-8.5	0.3-6.0	Low	C (moderately high runoff potential)
**B	5 to 40	5 to 25	channery loams	SM GM	A-2-4	20-30	NP	1.0-2.5	*0.1	7.5-8.2	0.7-3.0	Low	D (high runoff potential)
**Bs	10 to 60	5 to 25	channery sandy loams	SM GM	A-2-4	20-30	NP	1.5-3.0	*0.1	7.5-8.3	0.7-2.5	Low	D (high runoff potential)
Ds	5 to 10	150+	sandy loam to channery sandy loam	SM	A-2-4	20-23	NP	1.0-2.4	0.12-0.14	7.9-8.3	1.0-19.0	Low	B (moderately low runoff potential)
E	5 to 10	150+	fine sandy loams to loams	ML CL SM	A-4 A-6	20-27	NP-8	1.0-2.5	0.14-0.16	7.7-8.6	0.4-18.0	Low	B (moderately low runoff potential)
**F	3 to 7	10 to 40	loamy sands	SM	A-2	20-30	NP	2.0-4.0	*0.1	8.1-8.5	0.3-0.6	Low	D (high runoff potential)
**N	5 to 10	150+	fine sandy loam surface silty clay loam subsoil	CL	A-4 or A-6	20-30	5-15	0.05-0.20	0.14-0.16	8.1-8.9	5.0-15.0	Moderate	D (high runoff potential)
W	0 to 2	150+	silt loams to silty clay loams - some sands	CL SM	A-4 A-6	20-47	2-16	0.20-1.50	0.16-0.18	8.0-8.3	1.5-28.0	Moderate	B (moderately low runoff potential)

* less than
** estimate

¹See Section 8, USDA National Engineering Handbook

TABLE V-7

INTERPRETATIONS OF ENGINEERING PROPERTIES OF SOILS

Degree and Kind of Limitation for								Suitability as a Source of				Soil Features Affecting			
Soil	Septic Tank Absorption Fields	Sewage Lagoons	Sanitary Trench type	Sanitary Landfill Area type	Shallow Excavations	Dwellings w/without Basements	Local Roads & Streets	Roadfill	Sand	Gravel	Topsoil	Sanitary Landfill Cover Materials	Cover for Septic Shale Deposits	Pond Reservoir Areas	Dikes, Levees and Other Civil Works
A	Severe - slope depth	Severe - slope depth	Severe - depth slope	Severe - depth slope	Severe - depth slope	Severe - depth slope	Severe - depth slope	Good to fair A-2-4	Unsuited loam	Poor loam shallow	Poor channery & flaggy	Poor shallow	Poor shallow	shallow, slope	shallow, stones
As	Severe - slope depth	Severe - slope depth	Severe - depth slope	Severe - depth slope	Severe - depth slope	Severe - depth slope	Severe - depth slope	Good to fair A-2-4	Unsuited sandy loam	Poor sandy loam shallow	Poor very channery and flaggy	Poor shallow	Poor shallow	shallow, slope	shallow, stones
B	Severe - slope depth	Severe - slope depth	Severe - depth slope	Severe - depth slope	Severe - depth slope	Severe - depth slope	Severe - depth slope	Good to fair A-2-4	Unsuited loam	Poor loam shallow	Poor very channery and flaggy	Poor very shallow	Poor very shallow	shallow, slope	very shallow, stones
Bs	Severe - slope depth	Severe - slope depth	Severe - depth slope	Severe - depth slope	Severe - depth slope	Severe - depth slope	Severe - depth slope	Good to fair A-2-4	Unsuited sandy loam	Poor sandy loam shallow	Poor very channery and flaggy	Poor very shallow	Poor very shallow	shallow, slope	very shallow, stones
Cs	Slight - 5 to 10% slopes	Moderate - 5 to 10% slope	Slight	Slight	Slight	Slight	Slight	Good to fair A-2-4	Unsuited sandy loam	Unsuited	Fair Channer Content increases with depth	Fair to good	Fair to good	moderate to slow permeability	medium to high susceptibility to piping, medium shear strength
E	Slight - 5 to 10% slope	Moderate - 5 to 10% slope	Slight	Slight	Slight	Slight	Slight to moderate A-6 material in subsoil	Fair A-4 A-6	Unsuited sandy loam and loam	Unsuited	Fair to 20 cm strong Ca horizon below	Fair to good	Fair to good	moderate to slow permeability	medium to high susceptibility to piping, medium to low shear strength
F	Severe - depth	Severe - depth	Severe - depth	Severe - depth	Severe - depth	Severe - depth	Severe - depth	Fair A-4	Poor shallow loamy sand	Unsuited	Poor shallow loamy sand	Poor shallow loamy sand	Poor shallow	shallow, rapid permeability	shallow, medium to high susceptibility to piping
N	Severe - moderately slow permeability	Severe - moderately slow permeability	Moderate - moderately slow permeability	Moderate - moderately slow permeability	Slight moderate shrink-swell	Moderate - moderate shrink-swell	Moderate - moderate shrink-swell	Fair to poor A-4 A-6	Unsuited silty clay loam	Unsuited	Poor alkali salts	Poor alkali salts	Poor alkali salts	slow permeability, deep	medium to low shear strength
W	Severe - seasonal high water table, Flood danger	Severe - seasonal high water table, Flood danger	Severe - seasonal high water table, Flood danger	Severe - seasonal high water table, Flood danger	Moderate - seasonal high water table, Flood danger	Severe - flood danger, Season high water table	Severe - flood danger, Season high water table	Fair to poor A-4 A-6	Poor silt loam Inclusive of fine sand	Unsuited	Good silt loam poor fine sand	Good	Fair high salt content in subsoil	high water table	low to high susceptibility to piping, medium to low shear strength

"Moderate" means that the soil has limitations that can generally be overcome by proper planning, careful design, and good management.

"Severe" means that the soil limitations are severe enough to make the use of the soil questionable. Engineering designs to overcome the limitations are difficult and expensive.

The A, As, B, Bs, and F soils all have severe limitations, mainly because of steep slopes and shallow to very shallow soil mantles over bedrock. The Ds and E soils have slight limitations for most uses but have moderate limitations for sewage lagoons because of the 5% to 10% slopes. Because of the moderately slow permeability, N soils have severe limitations for septic tank drainage fields and sewage lagoons; the limitations for other uses are generally moderate. The soils are generally severely limited because of seasonal high water tables and flood danger.

Soils were rated for their suitability as a source of roadfill, sand, gravel, topsoil, sanitary landfill cover material, and spent-shale cover material. Suitability was rated in terms of "good," "fair," and "poor," which parallels the limitations terms "slight," "moderate," and "severe." Most of the soils were rated good to fair for roadfill material, based on AASHTO test data. The exceptions are the N and W soils, which were rated fair to poor. The soils were rated poor for sand or gravel.

The soils were rated poor for topsoil and as cover for sanitary landfill and spent-shale deposits if they were high in coarse fragments (channers and flaggs), shallow or very shallow to bedrock, and if they were moderately fine textured and contained alkali and salts. It should be noted that the soluble salt content increases markedly in the deeper subsoils, and therefore the upper 50 cm to 80 cm (20 in. to 31 in.) is usually best suited as a source of topsoil. The A, As, B, Bs, F, and N soils were rated poor, and the Ds, E, and W were rated fair to good. The D and W soils would be the best material for these uses, especially as cover for spent shale. The Southam Canyon area, where the spent shale will likely be deposited, contains about 259 ha (640 acres) of D soils. The W soils along the White River Valley contain some salt and would require transporting some distance to the spent-shale site. The suitable E soils would be good for all these uses, but they would be difficult to separate from the unsuitable N soils.

The soils were also rated in terms of features affecting use. Depth, slope, permeability, and water table affect soil use in pond-reservoir areas, and depth, stoney material, susceptibility to piping, and shear strength affect their use for dams, levees, and other embankment materials.

g. Soil Infiltration

The soil infiltration study was conducted to evaluate how the soils will be impacted by land-use changes. These data will also be used with the soils map to estimate runoff volumes by applying the U.S. Soil Conservation Service runoff calculations.

A Rocky Mountain infiltrometer was used to generate runoff from 96 small, movable 76-cm-X-30-cm plots (0.23 m² of soil surface coverage). The soils of most limited extent were not tested. Plots were installed by driving the edges 9 cm (3.5 in.) into the soil surface with a specially constructed hammer. An adjustable canvas wind shield was used to prevent wind disturbance and raindrop drift. Plots were pre-wet to field capacity (called "wet plots") prior to an infiltrometer run. Artificial rainfall was applied to the plots at rates of 10 cm to 15 cm (4 in. to 6 in.) per hr for 28 min. Rainfall and runoff rates were determined at 5-min intervals, and infiltration was the difference between these two measurements. Sediment-yield values were also obtained. All samples were taken during October 1974 and October 1975. The rate of application was high to simulate severe storms. Because infiltration rates tend to be lowest in the fall and because the applied rates were high, runoff values should be maximum. Sampling points are shown on Figure V-2.

Several limitations of these data must be considered. The principal limitation is the difficulty in simulating natural conditions with a small infiltration-test device and the few sites tested. Also, seasonal variations in soil infiltration rates were not tested. The data provided are best used to compare soil types.

Infiltration rates for wet soils are shown on Table V-8. Upland soils had rates of about 3.6 cm (1.4 in.) per hr. The soils of the bottomlands (D soils) had greater rates -- about 6.1 cm (2.4 in.) per hr. The soils formed on the alluvium of the White River (W soils) had much slower rates of uptake -- about 1.5 cm (0.6 in.) per hr. As expected, soils affected by excess sodium (N soils) had the lowest infiltration rates of all the soils tested -- about 0.8 cm (0.3 in.) per hr.

Infiltration rates did not decrease significantly during the 28-min period of the test; in fact most runs showed no time trend. Runs that did decrease with time had small magnitudes, approximately 1.3 cm (0.5 in.) per hr and were only apparent for the first 5 min of the run. In addition, soil type was apparently more significant than slope angle in determining infiltration rates. For these reasons,

infiltration data can be best summarized as a mean infiltration rate in each soil type.

Curve-number means and sediment-yield rates are also shown on Table V-8. The curve numbers can be used to calculate runoff using the SCS method. Since the rates are highly variable, the standard deviations are large. The estimates of sediment-yield are used primarily to compare soils.

A few sites were not wetted before testing. These dry sites provided some information on the infiltration rates of soils with little antecedent moisture. The infiltration rates of dry soils were a fraction of an inch per hour slower than those of wet soils on the same plots.

Infiltration rates, curve-numbers, and sediment-yields for all 96 plots are appendicized in the FYEBR.

h. Soil Radioactivity

The soils were measured to establish baseline levels of radioactivity in the area and to separate the sources from (1) radioactivity originating from nuclides within the oil shale (usually from nuclides in a uranium decay chain, which could affect the environment); (2) naturally occurring background activity; and (3) radioactivity identified with the world-wide fallout from weapons testing. The radiation levels in tract soils are primarily associated with naturally occurring background activity.

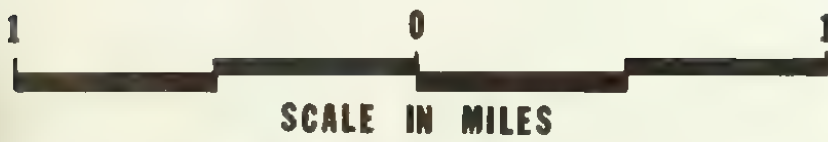
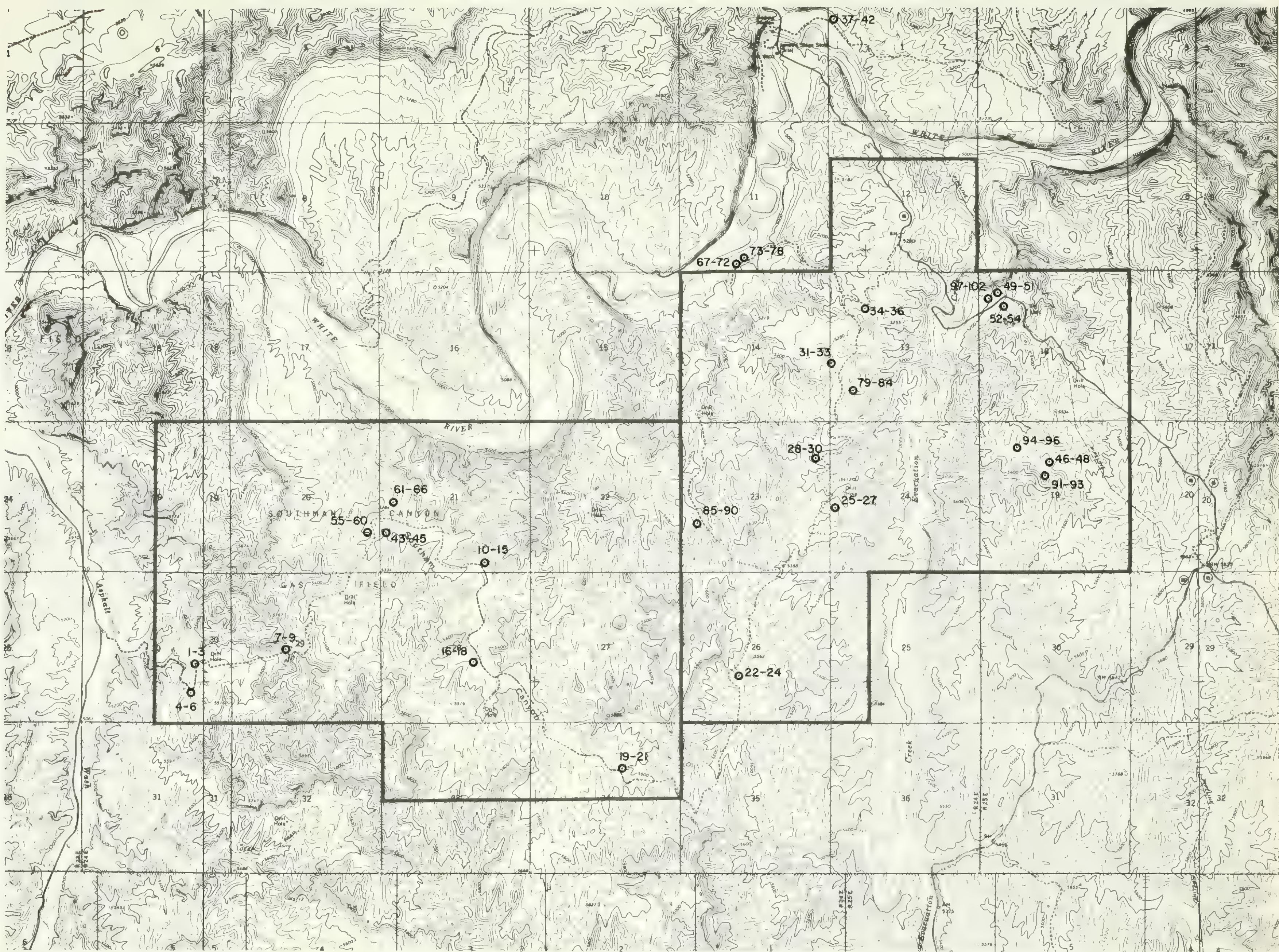
A number of soil samples were collected from representative locations on the two lease tracts and analyzed for radioactivity. No sources above a normal background level were identified, with Ra^{226} activity below 0.87 pCi/g; Sr^{90} below 0.52 pCi/g; K^{40} below 20.0 pCi/g, Pb^{212} below 1.5 pCi/g; and Cs^{137} below 1.6 pCi/g recorded for all samples. Detailed results of the soil radioactivity tests are appendicized in the FYEBR.

i. Trace Elements

The surface horizons of each of the soil series at the site were sampled to determine heavy-metal content for antimony, cadmium, fluorine, mercury, and selenium, as specified in the Revised Conditions of Approval of February 23, 1976. One sample was taken from the surface horizon of A, As, B, Bs, E, N, F, and W soils. Only the surface horizon (A1) of each soil type was sampled because it is lowest in pH, and subsequently the elements there are the most mobile

LEGEND

○ 7-9 FILTRATION PLOT NUMBERS



LOCATIONS OF SOIL INFILTRATION PLOTS

TABLE V-8
SUMMARY OF SOIL INFILTRATION RATES

<u>Soil Type (Antecedent Moisture Condition)</u>	<u>Mean Infiltration (in./hr)</u>	<u>±1 Std. Dev.</u>	<u>Mean Curve Number</u>	<u>±1 Std. Dev.</u>	<u>Mean Sediment Yield (tons/acre)</u>	<u>±1 Std. Dev.</u>
D _S (wet)	2.4	0.75	86	9.80	0.3	0.25
B _S (wet)	1.5	0.70	92	3.03	0.6	1.02
A (wet)	1.3	0.41	94	2.15	0.2	0.31
A _S (wet)	1.0	0.58	96	1.64	0.1	0.07
W (wet)	0.6	0.46	97	1.51	0.1	0.05
N (wet)	0.3	0.29	98	1.22	0.2	0.13
F (wet)	1.9	0.46	89	4.36	0.1	0.01
E (wet)	1.8	0.75	90	5.08	0.1	0.03
B (wet)	0.5	0.39	96	1.73	0.1	0.05
D _S (dry)	2.4	0.74	89	6.49	0.2	0.09
B _S (dry)	2.8	0.51	86	0.57	0.5	0.23

SOURCE: VTN

To convert from tons/acre to kilograms/hectare multiply by 2242.

and available. Also, organic matter is an important secondary source of some of the trace elements, and therefore in uncultivated profiles there is a somewhat greater concentration of trace elements near the surface.

The methods used to extract the elements from the soil do not give the total concentration but rather an approximation of the elements available to plants. Antimony and cadmium were extracted by the APDC method; fluoride and selenium, by hot water; and mercury, with a mild sulfuric permanganate digestion. Antimony and cadmium were read by atomic absorption; fluorine, using the SPADNS method; selenium, by DAN fluorimetry; and mercury, by flameless atomic absorption. The limits of sensitivity for the tests are 0.01 ppm for cadmium, mercury, and selenium; 0.02 ppm for fluorine; and 0.1 ppm for antimony. The results of the trace element study are listed on Table V-9.

Antimony (Sb)

Plant-available antimony was below the reporting minimum (0.1 ppm) in every soil, and therefore levels on the tracts are probably not deleterious. Antimony is probably similar in chemical behavior to arsenic, in that antimony is relatively unavailable for plant growth and uptake (the normal range of arsenic in soils is 0.1 ppm to 40 ppm).

Cadmium (Cd)

Cadmium is known to accumulate in animals, but there is little information concerning cadmium reactions in soil. The chemical similarity to zinc suggests that it should behave in soil much as zinc does; that is, at a pH of 6.5 and above it is of low availability to plants, especially if it is present in high valence forms. The soil probably ties up (retains) relatively large quantities of cadmium if the soil pH is high and the drainage good (Brady 1974). The concentration of cadmium in soils usually ranges from 0.1 ppm to 7 ppm. Cadmium concentrations in the soils of the site were less than 0.01 ppm in all samples and are therefore probably not deleterious.

Fluoride (F)

There is no report of fluoride toxicity from fluorides taken up by the roots of plants, translocated in the tops, and

TABLE V-9
RESULTS OF SOIL TRACE ELEMENT STUDY

<u>Soil</u>	<u>Sb</u>	<u>Cd</u>	<u>F</u>	<u>Hg</u>	<u>Se</u>
A	-.1	-.01	.4	-.01	-.01
W	-.1	-.01	1.1	-.01	-.01
As	-.1	-.01	.7	-.01	-.01
Bs	-.1	-.01	.7	-.01	-.01
E	-.1	-.01	1.0	-.01	-.01
F	-.1	-.01	.8	-.01	-.01
N	-.1	-.01	.8	-.01	-.01
B	-.1	-.01	.8	-.01	-.01
Ds	-.1	-.01	1.0	-.01	-.01

Minus sign indicates less than reporting minimums. All values are in parts per million.

eaten by animals (Allaway 1968). The fluorides formed in soils are highly insoluble, especially in soil well supplied with lime (Brady 1974). Fluoride is commonly found in soils in concentrations of between 30 ppm and 300 ppm. The Fluoride levels were well below 1.1 ppm in all samples, a level not considered deleterious.

Mercury (Mg)

Inorganic mercury compounds added to soil reacts quickly with organic matter and clay minerals to form insoluble compounds. In this form the mercury is unavailable to growing plants, although it can be converted to more available forms. Mercury levels at the site are probably not deleterious, since all were below the reporting minimums (0.01 ppm).

Selenium (Se)

Unlike the other elements tested, selenium in alkaline, well-aerated soil will oxidize to selenates that are not strongly absorbed or fixed, and are generally available to plants (Allaway 1968). The level normally found in soil is 0.1 ppm to 2.0 ppm. Soils containing 1 ppm of selenium may produce accumulated levels of up to 4 ppm in plants, which is toxic to most animals (Donahue 1971).

Dean Lansing, of Colorado Analytical Labs (pers. comm. 1976), noted that 0.1 ppm of available selenium in soils may be deleterious to plants or to the animals that feed on them. This would be unlikely in the soils of the site, since in all samples selenium levels were less than the reporting minimum (0.01 ppm).

j. Relationship Between Soils and Vegetation

Plant-available moisture is the most important factor in the distribution of vegetation types in the arid west, and soil characteristics are one of the important factors that determine plant-available moisture. As a result, the distribution of vegetation types often corresponds to the distribution of soil types. At the site, where vegetation-pattern and soil-type distribution coincide, it is usually a function of soil moisture.

Greasewood vegetation occurs exclusively on the D soils at the site. D soils are the deep, sandy loam soils forming in alluvium. They occur in the relatively narrow drainages

below steeply sloping soils and rock outcrops. The soil has a relatively high water-holding capacity. The correlation between areas of D soil and areas of greasewood vegetation is the closest of any of the soil-vegetation relationships at the site.

Riparian vegetation, as the name implies, is found only in areas adjacent to water and on moist soils. The soils of the site that are moist enough to sustain this type of vegetation are W soils and D soils. The W soils are deep, imperfectly drained, and form in silty alluvium adjacent to the flood plain of the White River. All of the W soils mapped at the site support riparian vegetation. Riparian vegetation also occurs along Evacuation Creek where D soils are moist enough.

The upland soils at the site are similar to one another, but support a variety of vegetation types. The juniper type is found at the high elevations on the thin sandy soils -- As, Bs and F. These are shallow and very shallow sands, sandy loams, or loams. The eastern limits of juniper roughly coincide with the limits of these soils along the west side of Evacuation Creek. However, the same soils extend beyond the limits of the juniper type because juniper is limited by its attitudinal requirements. The thin sandy soils that are below the juniper-vegetation limits to the north and to the west are dominated by big sagebrush.

The A and B soils have formed on the Green River Formation. Very shallow loam soils, they are less sandy than the upland soils found on the Uinta Formation. The vegetation on these soils is exclusively the shadscale-black sagebrush type. The shadscale-black sagebrush type is not limited to soils A and B, but also dominates the sandy soils (As, Bs, and F) that occur north of the White River.

3. INTERPRETATION AND CONCLUSIONS

The soils of Tracts U-a and U-b are mainly shallow to very shallow soils, less than 50 cm (20 in.) deep, on sloping to steep upland terraces cut by numerous intermittent drainages and containing many areas of rock outcrops and rock escarpments.

Soils A, As, B, Bs, and F are included in these shallow sites. They consist of sandy loam, loams, channery sandy loams, and channery loams. The course-fragment content (channers and flaggs) usually increases with depth, and numerous flagstones with a small proportion of soil occurs immediately above the bedrock. Surface soils are light

colored and moderately calcareous. The CaCO_3 (lime) content usually increases with depth and occurs as a coating on the undersides of rock fragments.

There are numerous drainageways throughout the tracts. Most of them have intermittent stream channels, and the soils -- usually Ds soils -- along these channels are generally deep (more than 150 cm [59 in.]), mainly sandy loams or channery sandy loams, light colored, and moderately calcareous. They are the most extensive in the Southam Canyon drainage area.

Along the Evacuation Creek drainage the Ds soils are associated with N soils. The N soils are deep and moderately fine textured and are strongly alkaline with a high concentration of exchangeable sodium. The N soils also occur on stream terraces about 15 m to 30 m (50 ft to 100 ft) above the White River flood plain. In these areas the N soils occur with E soils, which are deep and moderately coarse textured with a strong CaCO_3 (lime) horizon in the subsoil.

The W soils occur adjacent to the White River, mainly in the corridor outside the tracts. They are deep and silty and seasonally wet in the deeper horizons. They generally have a high salt content.

Infiltration rates vary with the soil type. The upland soils (A, As, B, Bs, F) have rates of about 3.6 cm (1.4 in.) per hr. The soils of the bottomlands (D) have greater rates -- about 6.1 cm (2.4 in.) per hr. The soils formed on the alluvium of the White River (W soils) have much slower rates of uptake -- about 1.5 cm (0.6 in.) per hr. As expected, soils affected by excess sodium (N soils) have the lowest infiltration rates of all the soils tested -- about 0.8 cm (0.3 in.) per hr.

The soils were measured for radioactivity. No sources above a normal background level were identified.

4. EVALUATION OF THE BASELINE PROGRAM

The soil baseline program is completed and has complied with the lease stipulations to conduct a soil inventory of the site that meets the requirements of the National Cooperative Soil Survey. The entire site and a 1.6-km perimeter of the site was mapped, all the soils present were sampled and tested, and interpretations were made. In addition, the soils were classified by basic engineering characteristics and interpreted as to their suitability for various uses. The soils information collected and the data

concerning vegetation, soil microbiology, climate, and wildlife can be used to evaluate the productivity of the ecosystems at the site.

The soil baseline program has adequately defined existing soil conditions at the site for some purposes but not for all. The information should be sufficient to predict development-related impacts to the soils of the site and to design impact mitigation measures. The baseline program is not sufficient for soil engineering design, since that is not within the framework of a soil survey. The information is also insufficient for detailed reclamation planning: areas selected for use as topsoil in reclamation on the basis of this survey should be mapped and sampled in more detail prior to stripping.

Soils will not lend themselves to a monitoring system for determining impacts from development. The single best method of accessing impacts to soils is to monitor suspended sediment in runoff from the drainages of disturbed areas and compare that to pre-disturbance values. In this environment almost any activity that stresses the soil will have the net effect of increasing erosion and hence suspended sediments.

There are no parameters that can be measured to monitor impacts to soil directly. If soils of the site are greatly impacted by development, reference to the baseline study would reveal the degree of impact. Other ecological parameters (particularly water quality) would be much more sensitive and would indicate impacts before any soils monitoring system.

B. GEOLOGY

1. METHODOLOGY

All surficial geologic data and most of the subsurface data were reported in the First Year Environmental Baseline Report (FYEBR). The only subsurface geologic data collection not reported relates to supplemental drilling and testing conducted subsequent to the FYEBR. Data concerning the supplemental program will be discussed in detail in this report; the findings presented in the FYEBR will be highlighted, and the reader is referred to the earlier report for more detail.

Geologic data were gathered in response to the Federal Oil Shale Lease Stipulations, the Partial Exploration Plan, the Geologic Exploration Program Supplement, and the Conditions of Approval of the plan and supplement. The data

are regional and site specific. Site data include surface and subsurface data for the 41.4 sq km (16 sq mi) of Tracts U-a and U-b as well as land within 1.6 km (1 mi) of the tract boundaries. Regional data is for the Uinta Basin, particularly the southeastern part.

Topics included in the first-year report are physiography, geologic history, stratigraphy, structure, hazards, mineral resources, aquifers, and the oil shale mining zone. The physiography section includes information about landforms, geomorphic processes, slope, elevation, stream characteristics, and climate. The stratigraphic section includes regional and site-specific descriptions of Eocene and Quaternary strata. Significant aquifers within the strata are identified. Regional and site-specific strikes and dips of strata, folds, faults, and joint patterns are included within the description of structural geology. Possible hazards discussed include earthquakes, landslides, rockfall, and subsidence. Mineral resources described are oil shale, oil, natural gas, gilsonite, bituminous sandstone, coal, uranium, gypsum, nahcolite, and alumina. Analyses to determine the grades of oil shale, nahcolite and extractable alumina within the mining zone are included. In addition, the depth, extent, and stratigraphic position of the mining zone and trace-element concentrations within the zone are given. Drilling locations are shown on Figure V-3; types of data developed are shown on Table V-10.

2. SUMMARY OF RESULTS

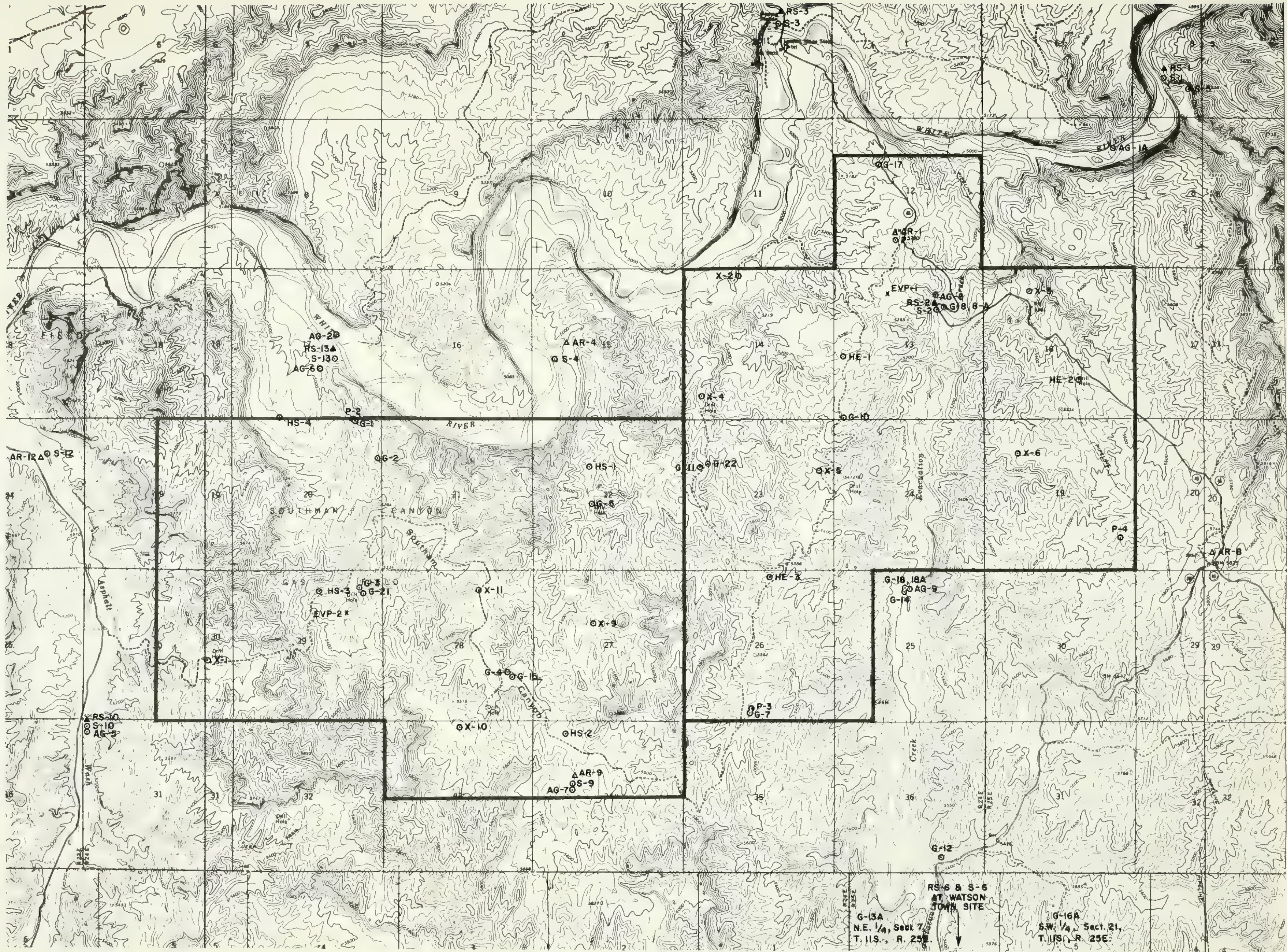
a. Physiography

Tracts U-a and U-b are within the eastern portion of the Uinta Basin, a broad, northwest-facing asymmetric basin on the northeastern edge of the Colorado Plateau (Figure V-4). The Uinta Basin overlies alluvial sediments of a prehistoric depositional lake basin. Major land features bordering the basin are the Uinta Mountains on the north, the Wastach Range on the west, the Roan Cliffs on the south, and the highlands associated with the subsurface Douglas Creek Arch along the eastern edge.

Tracts U-a and U-b are bounded by the White River to the north, Hells Hole Canyon to the east, upland areas of elevations between 1829 m and 1890 m (6000 ft and 6200 ft) to the south, and Asphalt Wash to the west. The region near the tracts, including all the area extending southward to the Roan Cliffs and westward to the Green River, is a gently north-sloping, highly dissected plateau characterized by steep-walled canyons with ephemeral streams or dry washes.

LEGEND

- S SURFACE WATER MONITORING STATION
- P PILOT TEST HOLE (WATER)
- G GROUND WATER MONITORING STATION
- HE EXISTING GEOLOGIC CORE HOLE, EVACUATION
- HS EXISTING GEOLOGIC CORE HOLE, SOUTHAM
- X EXPLORATION GEOLOGIC CORE HOLE
- AG ALLUVIAL WELL (WATER)
- △ AR PRECIPITATION, AUTO (WATER)
- ▲ RS PRECIPITATION, STORAGE (WATER)
- * EVP EVAPORATION PAN (WATER)



WATER AND GEOLOGIC RESOURCES BASELINE MONITORING STATIONS

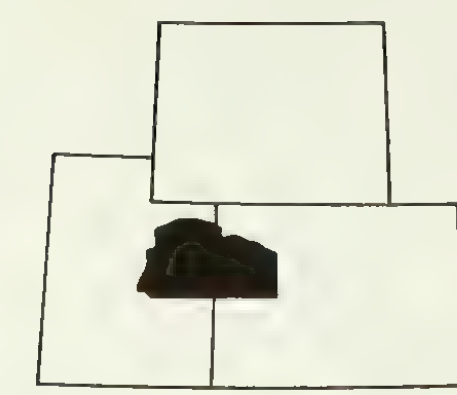
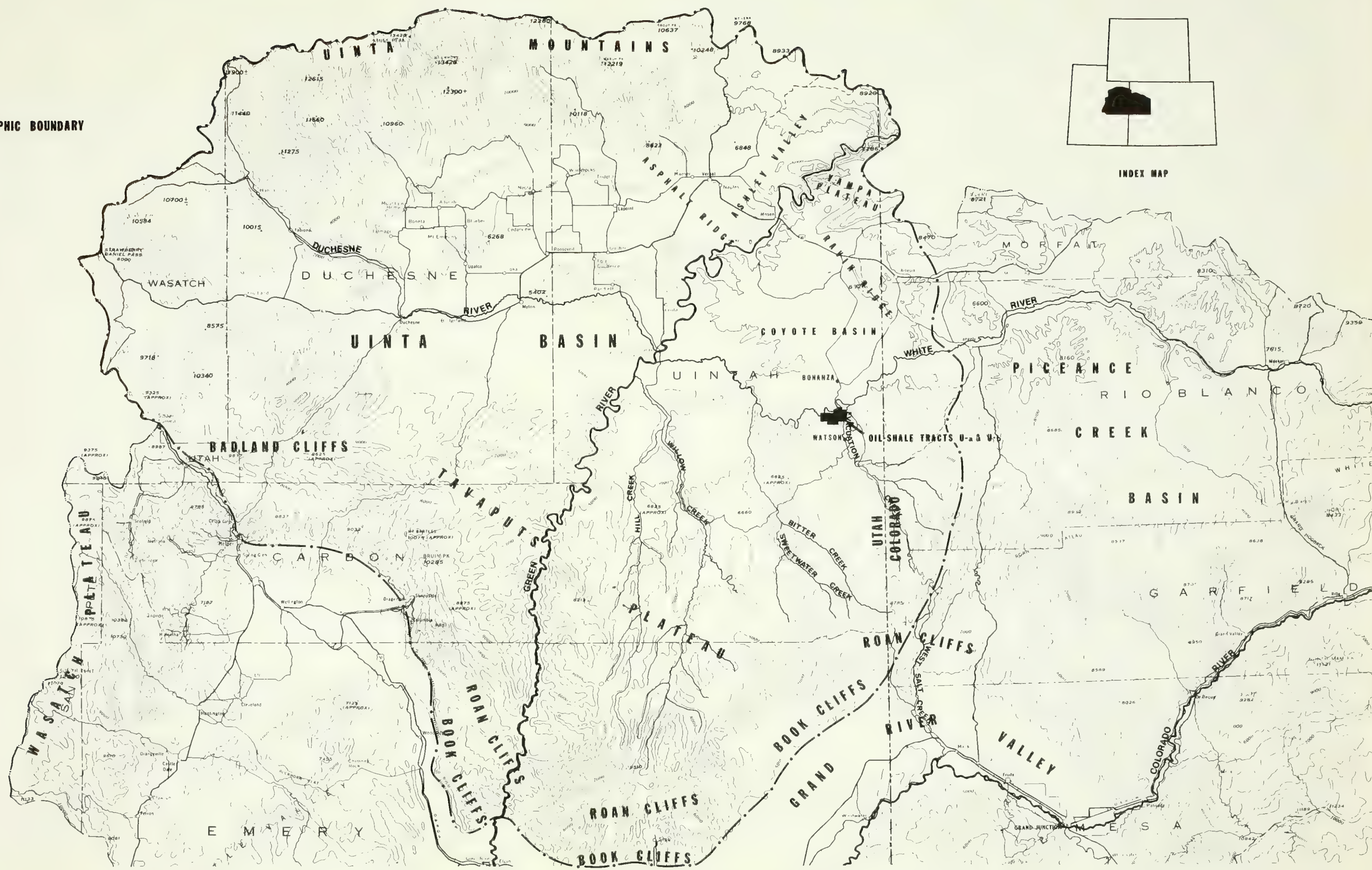
FIGURE V-3

TABLE V-10
DATA COLLECTED FROM
THE P, X, AND G HOLES

	P-Holes (4)	X-Holes (9)	G-Holes (29)
Cored Interval	entire hole below sur- face casing	from approx- imately 130' above to 120' below the Mahogany marker bed (a key bed lying 3-9 meters above the richest mahogoney beds)	none
Geologic Log	entire hole	generally from entire hole	entire hole
Geophysical Logs			
natural gamma	yes	yes	yes
gamma gamma	yes	no	yes
neutron gamma	yes	no	yes
neutron	no	yes	no
neutron neutron	yes	no	yes
spontaneous potential	yes	yes	yes
fluid resistivity	yes	yes	yes
resistivity (64" normal)	yes	yes	no
lateral electric	yes	no	no
caliper	yes	yes	yes
spinner	yes	yes	yes
fluid temperature	yes	yes	yes
density	no	yes	no
three-dimensional velocity	no	yes	no
Water Conditions			
flow	yes	yes	yes
conductivity	yes	yes	yes
temperature	no	yes	no
static level	yes	yes	yes
Aquifer Tests			
packer	yes	X-3, X-11 only	yes
slug	yes	no	no
pump	yes	no	no

TABLE V-10 (Cont.)

	P-Holes (4)	X-Holes (9)	G-Holes (29)
Fisher Assays	yes	yes	no
Rock Mechanics Tests	yes	yes	no
Chemical Analyses			
extractable alumina	yes	yes	no
nahcolite	yes	yes	no
boron	yes	yes	no
mercury	yes	yes	no
cadmum	yes	yes	no
flouride	yes	yes	no
antimony	yes	yes	no
arsenic	yes	yes	no
selenium	yes	yes	no
molybdenum	no	yes	no



PHYSIOGRAPHIC MAP OF THE UINTA BASIN REGION

The elevations on Tracts U-a and U-b range from 1500 m to 1890 m (4920 ft to 6200 ft) for a maximum relief of 390 m (1280 ft), as seen on Figure V-5. In general, the lands within Tracts U-a and U-b slope north toward the east-west-trending channel of the White River.

Geomorphology

In the southeastern Uinta Basin, intertributary divides between major drainages are broad and capped by resistant rock strata that dip northwestward more steeply than the plateau surface to create narrow, bench-like mesas, cuerdas, and hogbacks. Northward from the White River and east of the Green River the landscape is typical badland topography consisting of many short, minor drainages with steep angular slopes, but only moderate relief. This area is prone to flash flooding and extreme erosion (Clark 1957).

Within the tracts the landscape is composed of a series of north-south-trending valleys separated by narrow, elongated mesas. Proceeding from east to west, three dominant ridge sections trend just west of north, north, and just east of north. The maximum dimensions of these landforms are oriented perpendicular to the direction of the White River. A mesa interfluvium with elevations of between 1646 m and 1707 m (5400 ft and 5600 ft) lies in an east-to-west transect through the central portion. The mesa slopes downward to a bench with elevations of between 1585 m and 1646 m (5200 ft and 5400 ft) and slopes down to Evacuation Creek. Continuing westward, the topography rises to elevations of between 1646 m and 1707 m (5400 ft and 5600 ft) and again drops to Southam Canyon. West of Southam Canyon, elevations increase to over 1737 m (5700 ft) and then slope downward to Asphalt Wash, which is generally below 1524 m (5000 ft).

Geologic structure and erosion have influenced the development of several landforms on Tracts U-a and U-b, especially rock pinnacles and balanced rocks. These numerous and prominent forms on or near ridgetops have developed by progressive headward erosion by drainages along vertical fractures or joints. Over a long period this process has left large isolated blocks of standing rocks which are enhanced by the presence of a more resistant caprock. In addition, large rock faces on canyon walls along the White River show evidence of massive rock failures. These have occurred along vertical fractures that are generally perpendicular to the bedding.

Drainage Basin Form and Process

The overall drainage pattern of the Uinta Basin is predominantly dendritic, but along the stream channels there are many straight reaches caused by the northwest-trending and north-east-trending sets of joints in the surficial rock formations. Larger streams of the basin have well-developed, meandering channels within their relatively straight, steep-walled flood channels. The Green River, flowing generally southwestward, is the master drainage within the basin. The majority of its water comes from the westward-flowing White River system and the eastward-flowing Duchesne River system.

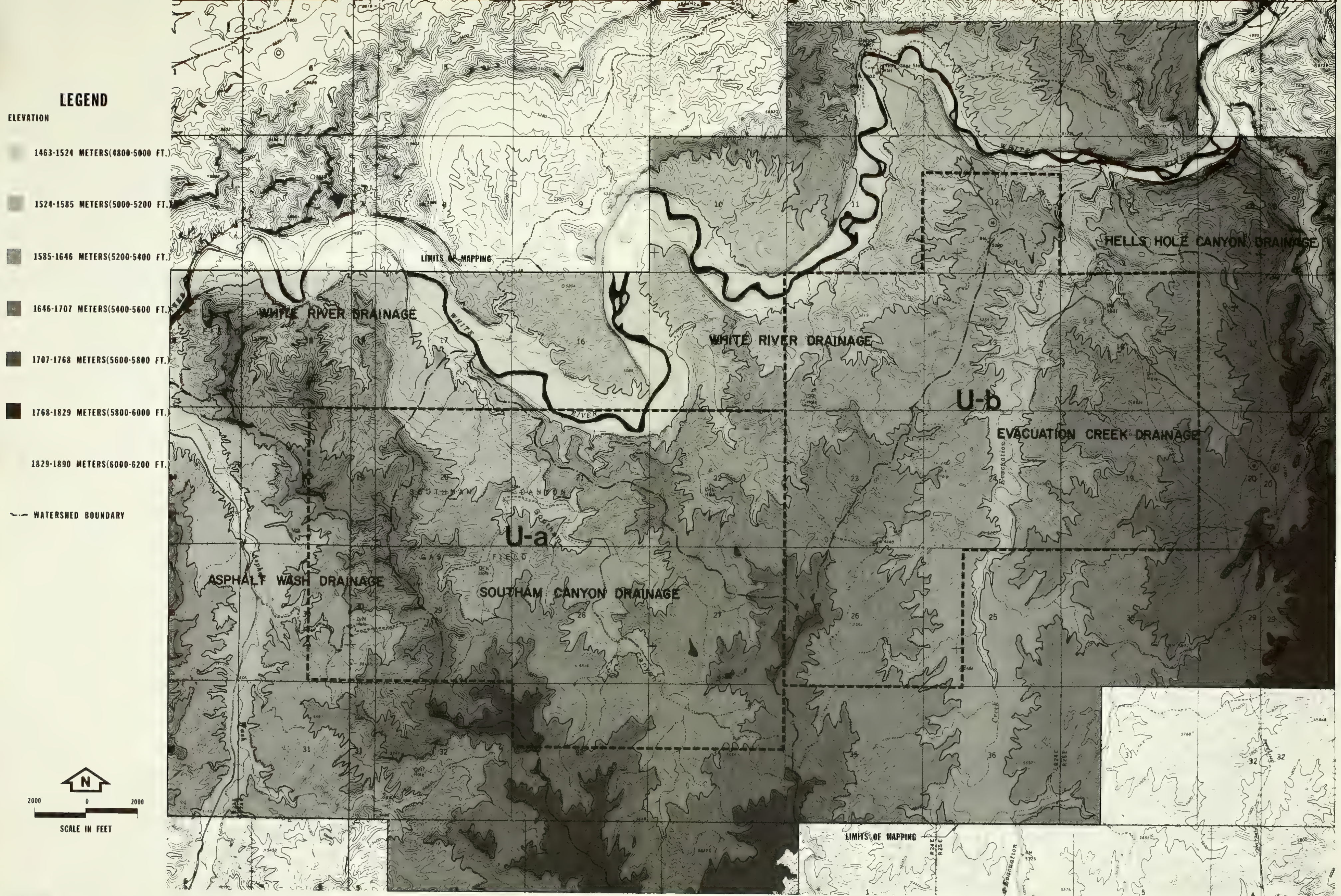
Thirty-three percent of the tracts is in the Evacuation Creek drainage basin, 31% is in the Southam Canyon drainage, 30% drains directly into the White River, and another 6% is in the Asphalt Wash drainage. The White River is the only perennial stream running through the tracts, although Evacuation Creek contains surface flow for several months of the year, mainly from ground water discharge. Southam Canyon, Asphalt Wash and tributaries of Evacuation Creek and the White River are all ephemeral.

Several factors influence drainage and pattern on the tracts. Surficial outcrops of the Parachute Creek Member of the Green River Formation have a higher drainage density than do those of the Uinta Formation. Orientations of relatively straight tributaries correlate strongly with the joint (rock fracture) orientation pattern in NE $\frac{1}{4}$, Sec. 22 T10S, R24E, and the lower half of Southam Canyon (figures V-5, V-6, and V-7). The more level portions of land near the river have a fine-textured (dissected) drainage density, while upland areas of the Uinta Formation remain relatively coarse textured (undissected).

Fluvial landforms along the White River are dominated by point bars, longitudinal channel bars, and cut banks. The deepest pools occur on the outside of the stream channel where the meander loops have the greatest radius of curvature. Small alluvial fans exist where Evacuation Creek and lesser tributaries join the White River.

b. Geologic History

In its early stages of formation, during the Paleocene Epoch, the Uinta Basin was the northeastern portion of a much larger basin that spread over most of Utah. Beginning with the Early Eocene Epoch, Lake Uinta covered the entire Uinta

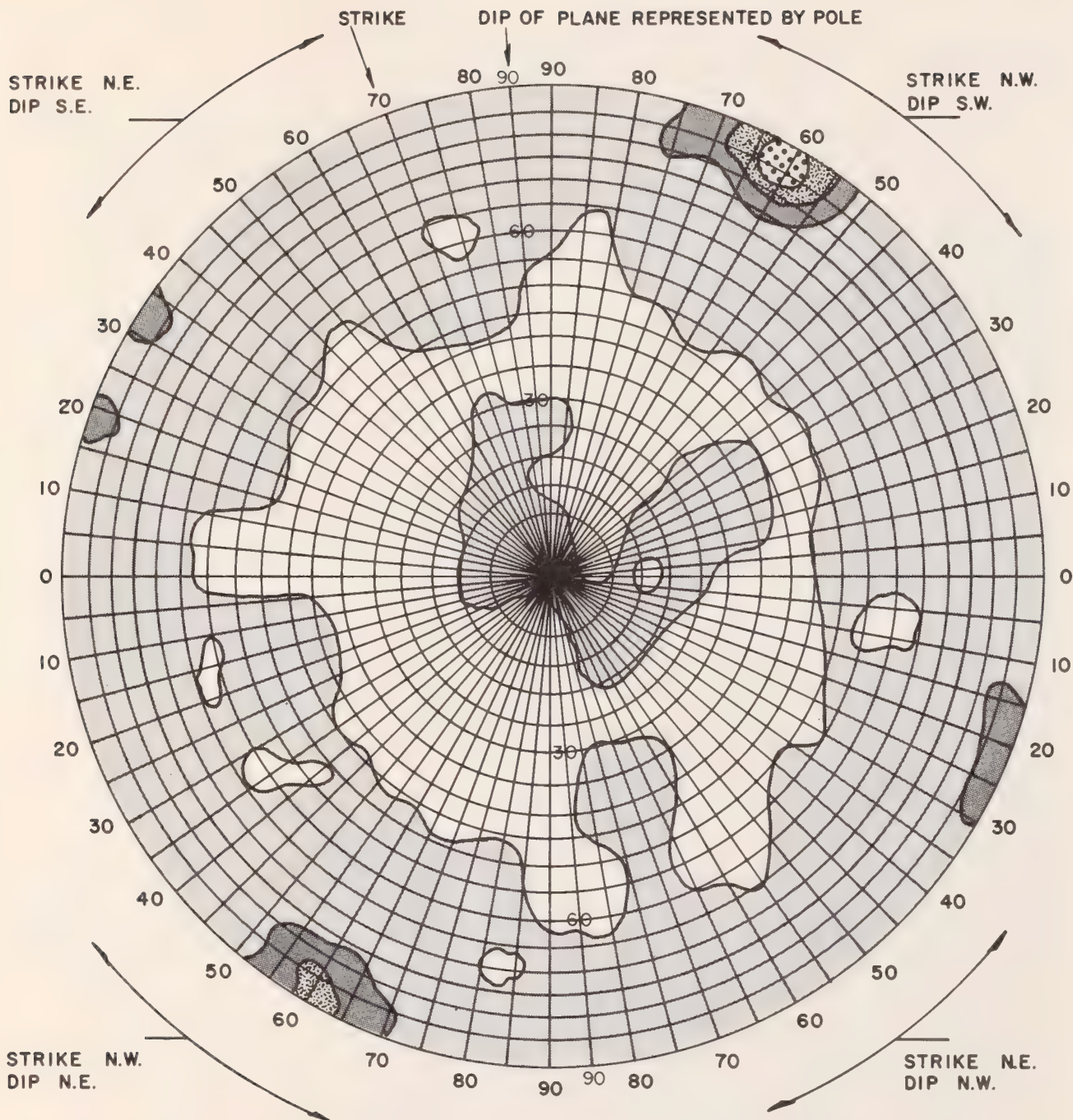


DRAINAGE BASIN SHADED RELIEF MAP



STRUCTURAL GEOLOGIC MAP OF OIL-SHALE TRACTS U-a & U-b , UINTAH COUNTY, UTAH

FIGURE V-6



PURPOSE

ANALYSES OF PRINCIPLE JOINT SYSTEMS

AVERAGES

PRIMARY SET ... N62W/86SW

SECONDARY SETS ... N22E/88NW
N18E/88SE
N33E/87SE

LEGEND

CONTOUR INTERVAL IN PERCENT OF TOTAL SAMPLE

0-5
5-10
10-15
15-20

COUNT DIAGRAM OF POINTS REPRESENTING JOINT
ORIENTATIONS, TRACTS U-a & U-b

FIGURE V-7



and Piceance Creek basins and possibly connected with another large lake that covered most of southwestern Wyoming. By the close of the early Eocene Epoch, this lake basin had dried up after accumulating a thick sequence of deep sediments from the surrounding highlands to form the present configuration of the Uinta Basin.

The sequences of strata that crop out in this region reflect the different stages of the basin's evolution. The oldest sediments, deposited during the initial stages of basin formation, constitute the Wasatch Formation. These sediments were deposited primarily along streams flowing southward from the Uinta Mountains area and along deltas of streams on the northern edges of ancient Lake Flagstaff. While Lake Uinta existed in its maximum dimensions, the Green River Formation sediments and organic matter accumulated on the lake bottom. As the lake size diminished because of further rise of the Uinta Mountains and the Douglas Creek Arch, alluvial sediments of the Uinta Formation and Duchesne River Formation were spread over the surface of the Uinta Basin by meandering streams that flowed toward the lower, central portions of the basin (McDonald 1972).

c. Stratigraphy

The rock formations studied as part of this report were deposited during the Eocene Epoch and the Quaternary age. The outcrop patterns of rocks in the vicinity of the tracts are shown on Figure V-8 and a regional cross section through the tracts is shown on Figure V-9. These formations are described in detail in the FYEBR.

d. Structural Geology

The geologic structure at the site is uniform. The strata generally dip less than 5° (below horizontal) toward the north or northwest and have no known faults. Within the proposed mining zone dip is generally 28 m/km to 47 m/km (150 ft/mi to 200 ft/mi) toward the northwest. The orientation of the strata is shown on Figure V-10.

Minor folds -- a result of soft-sediment deformation -- are found only in the lower part of the Uinta Formation and in the uppermost part of the Green River Formation; the folds are too small to map. Each symbol represents the orientation of a planar surface, either bedding or jointing.

Sets of near-vertical joints (rock fractures) occur throughout the site area. Since the joints are crucial to the

LEGEND

0-6% (0-3°) :
LEVEL TO GENTLY SLOPING

7-14% (3-6°) :
UNDULATING TO ROLLING

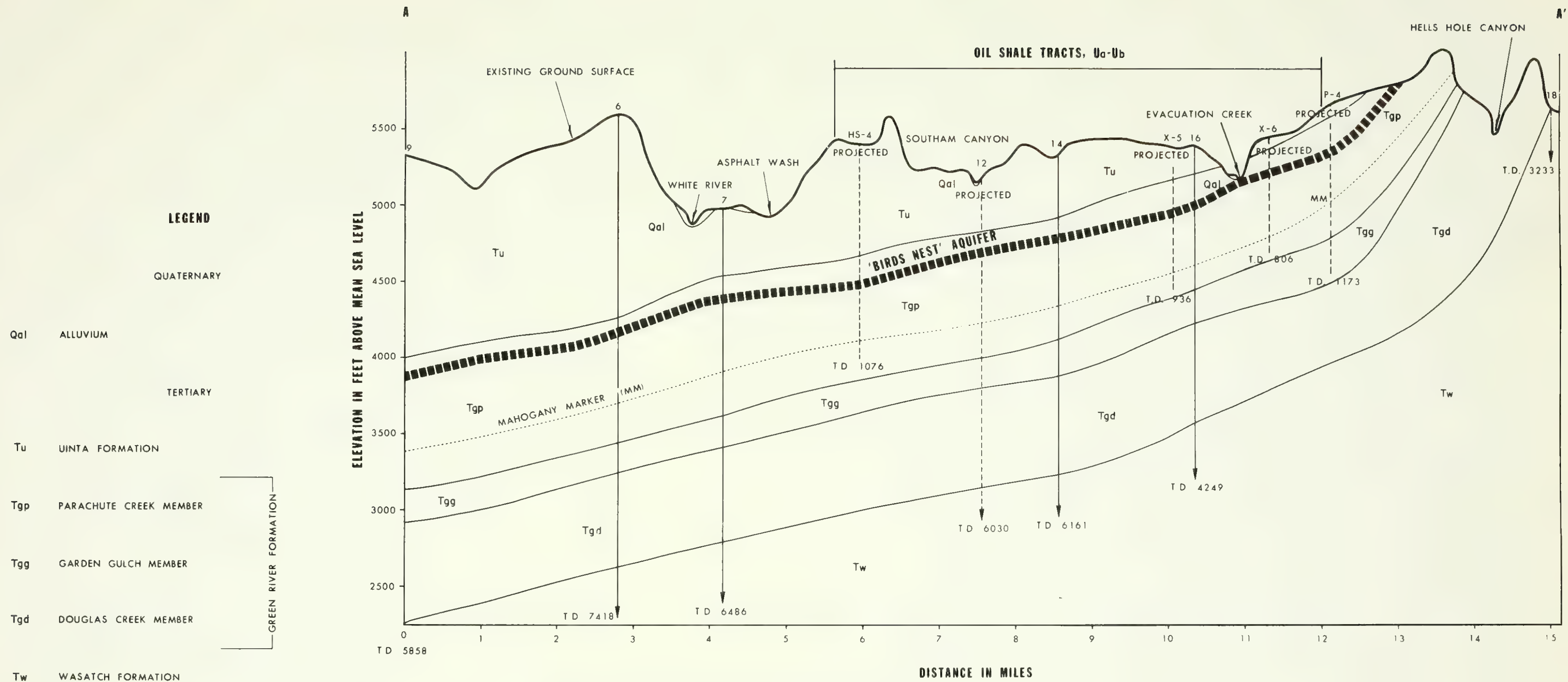
15-30% (7-13°) :
ROLLING TO HILLY

31-50% (14-22°) :
HILLY TO STEEP

≥ 51% (>23°) :
STEEP AND VERY STEEP



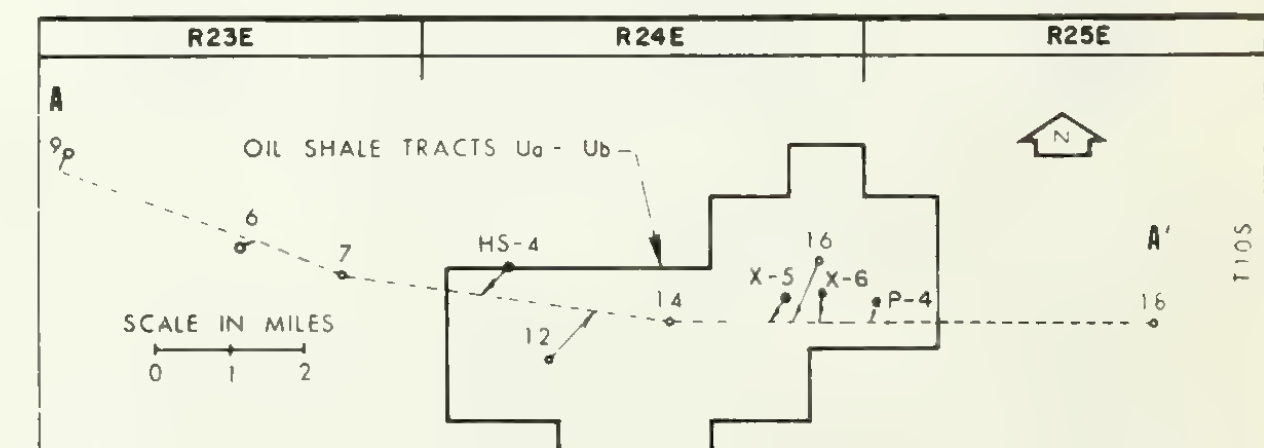
SLOPE GRADIENT MAP - TRACTS U-a & U-b



OIL AND GAS TEST WELLS WITH GEOPHYSICAL LOGS

MAP NO	OPERATOR	DESCRIPTION
9	BELCO	TEXOTA #1
6	EL PASO N.G. CO	SOUTHAM CANYON #3
7	SHELL OIL	SOUTHAM CANYON #7
12	EL PASO N.G. CO	SOUTHAM CANYON #4
14	MOAB DR. CO	GEM #1
16	CONTINENTAL OIL CO.	#1 AA 120 WATSON
18	OIL INC.	BONANZA #2

LOCATION OF CROSS-SECTION



REGIONAL GEOLOGIC CROSS-SECTION
THROUGH OIL SHALE TRACTS Ua-Ub



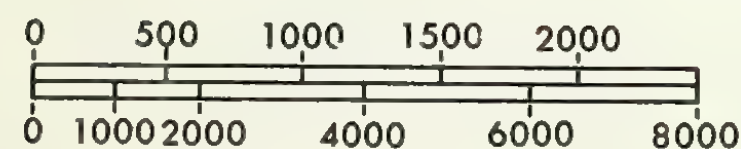
LEGEND

- P PILOT TEST HOLE
- G GROUND WATER MONITORING STATION
- HE EXISTING GEOLOGIC CORE HOLE, EVACUATION
- HS EXISTING GEOLOGIC CORE HOLE, SOUTHAM
- X EXPLORATION GEOLOGIC CORE HOLE

CONTOUR LINES SHOWING ELEVATION IN METERS (FEET) ABOVE SEA LEVEL OF THE MAHOGANY MARKER BED. A VOLCANIC TUFF BED WHICH LIES APPROXIMATELY 3-5 METERS (9-15) FEET ABOVE THE MAHOGANY OIL SHALE BED. CONTOURS DASHED WHERE INFERRED.

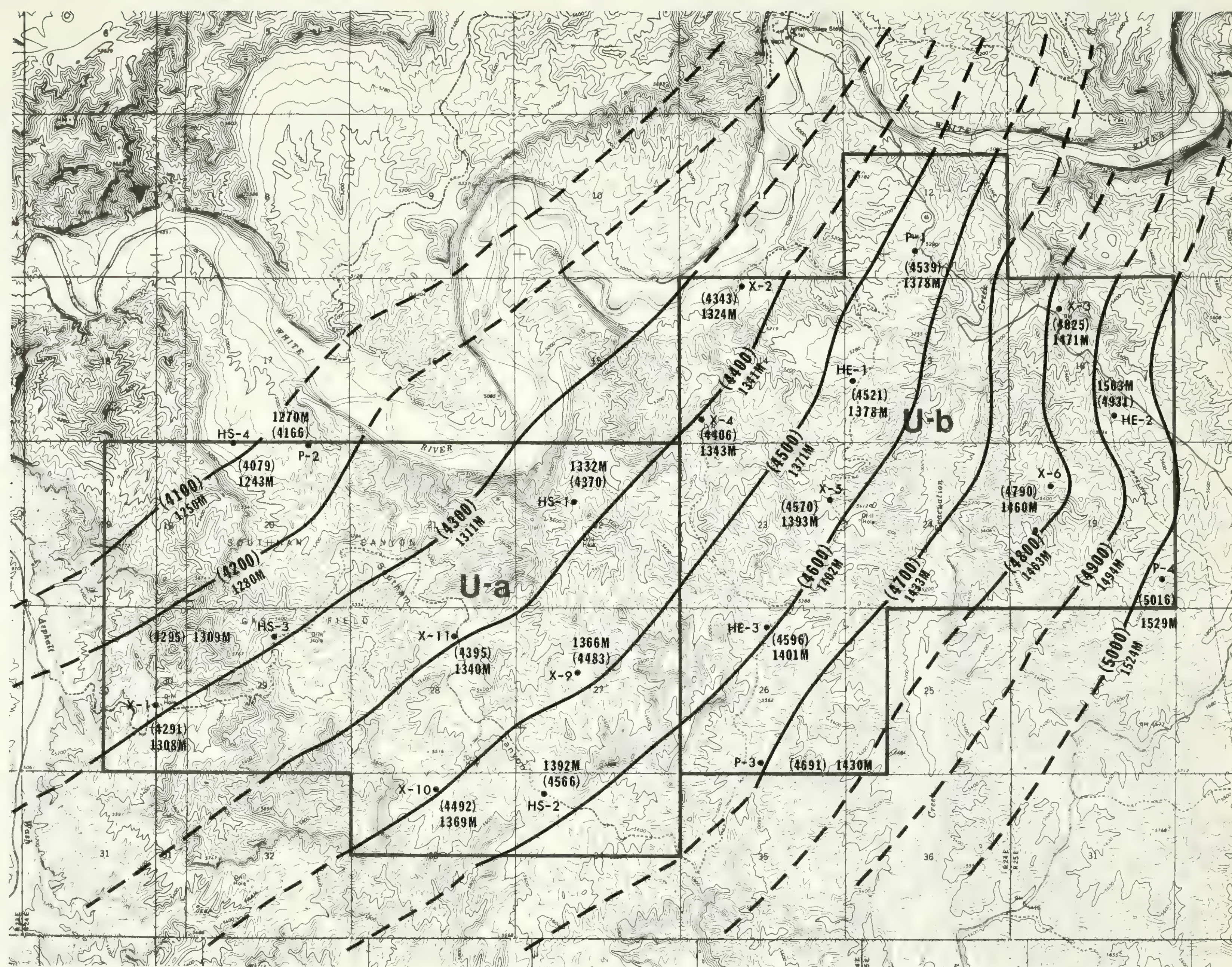


SCALE



METERS

FEET



SUBSURFACE STRUCTURAL CONTOUR MAP OF THE MAHOGANY MARKER BED, TRACTS U-a & U-b

FIGURE V-10

overall strength and stability of the strata, they have been mapped and analyzed in detail. In this process each mapped joint orientation was plotted as a point (pole) on a circular grid according to its strike and dip. Then, based on the density of the poles falling within different areas of the grid, the percentage of contour was diagrammed (see figures V-7 and V-11 through V-13). These diagrams show the joint set orientations of primary, secondary, and tertiary importance in the mine area.

Within the site, the primary set of joints trends north 62° west and dips 86° northwest. The three secondary sets trend north 22° east, north 18° east, and north 33° east. These secondary joint sets dip 88° northwest, 88° southeast, and 87° southeast, respectively.

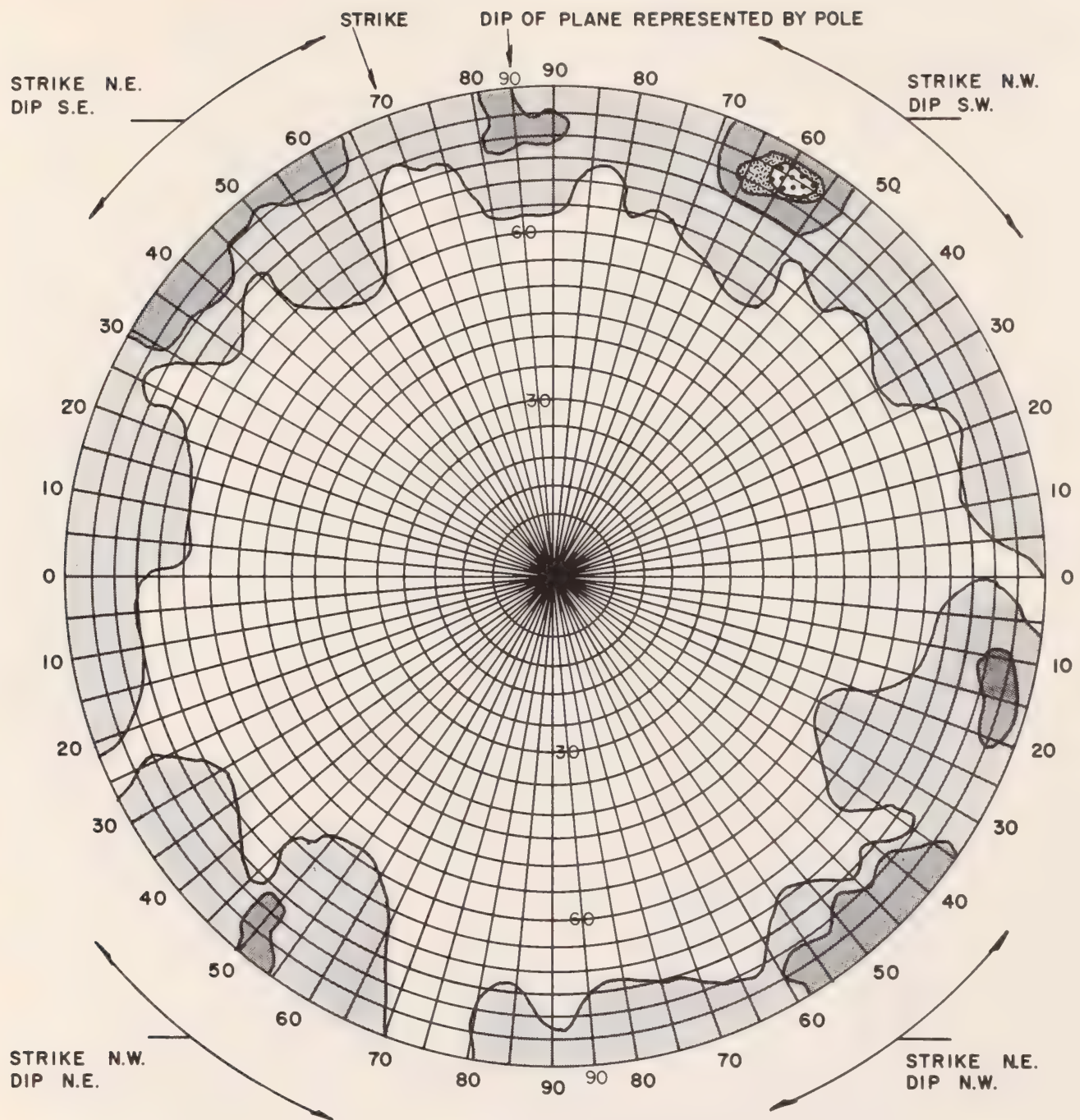
The physical character of the joints in the Uinta Formation is extremely variable. Smooth, large, flat, open joints are the most noticeable; however, there are also numerous small, rough, closed joints throughout the section. Figure V-14 is a detailed stratigraphic description of joint character, spacing, length, and orientation within the most extensively exposed unit. The joints also vary within the Green River Formation, although they are mostly smooth, open, and flat (see Figure V-15).

Investigations of rock mechanics were conducted to evaluate the physical characteristics of the groundmass immediately above, within, and below, the oil shale zone to provide design criteria for underground mine development. Tests were run on selected intervals of cores from the X-holes and P-holes. These included deformation tests, uniaxial and triaxial compression tests to destruction, Brazilian tests, and density determinations. The tests were run on the intervals of core shown on Table V-11. The results of these tests were submitted directly to the WRSP and the AOSS by Cleveland Cliffs Iron Company.

e. Geologic Hazards

Seismicity

Seismic risk is defined as the probability of earthquake damage from ground shaking, subsidence, differential settlement, ground cracking, or liquefaction. Three zones of seismic risk, based on historical earthquake occurrence, have been identified for the western U.S. (Figure V-16). Tracts U-a and U-b lie within the lowest risk zone. No active surface faults have been reported in the vicinity of the tracts.



PURPOSE

ANALYSES OF PRINCIPLE JOINT SYSTEMS

AVERAGES

PRIMARY SET ... N57W/84SW

SECONDARY SET ... N59E/86SE
N46E/89NW

TERTIARY SET ... N85E/83SE
N17E/85NW
N51W/86NE

LEGEND

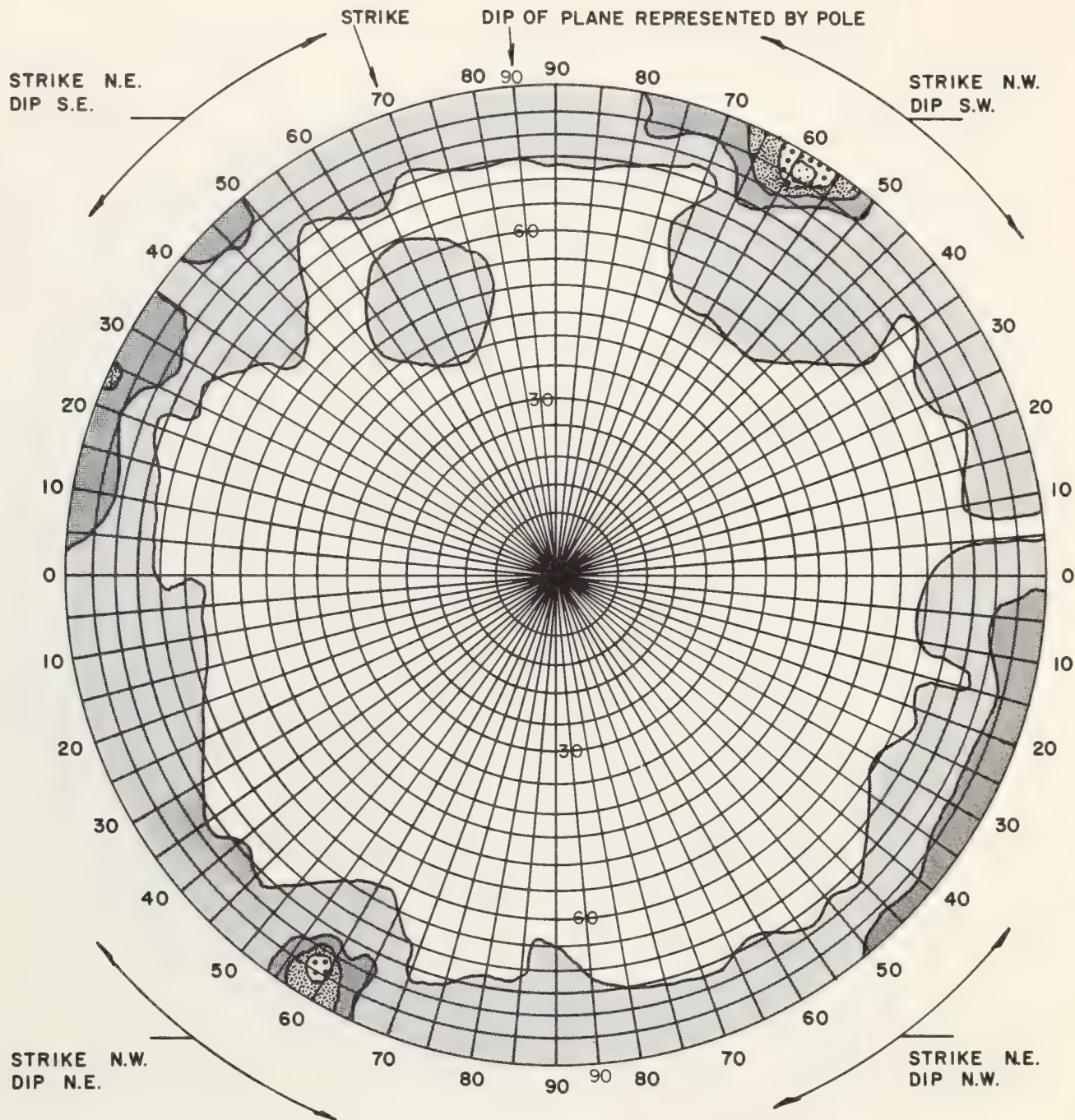
CONTOUR INTERVAL IN PERCENT OF TOTAL SAMPLE

	0-5
	5-10
	10-15
	15-20

COUNT DIAGRAM OF POINTS REPRESENTING JOINT PLANE
ORIENTATIONS, SEC. 23, 24 & 26, T10S, R25E

FIGURE V-12





PURPOSE

ANALYSES OF PRINCIPLE JOINT SYSTEMS

AVERAGES

PRIMARY SET ... N59W/86SW
N58W/84NE

SECONDARY SET ... N24E/89SE
N24E/89NW

TERTIARY SET ... N45E/88SE

LEGEND

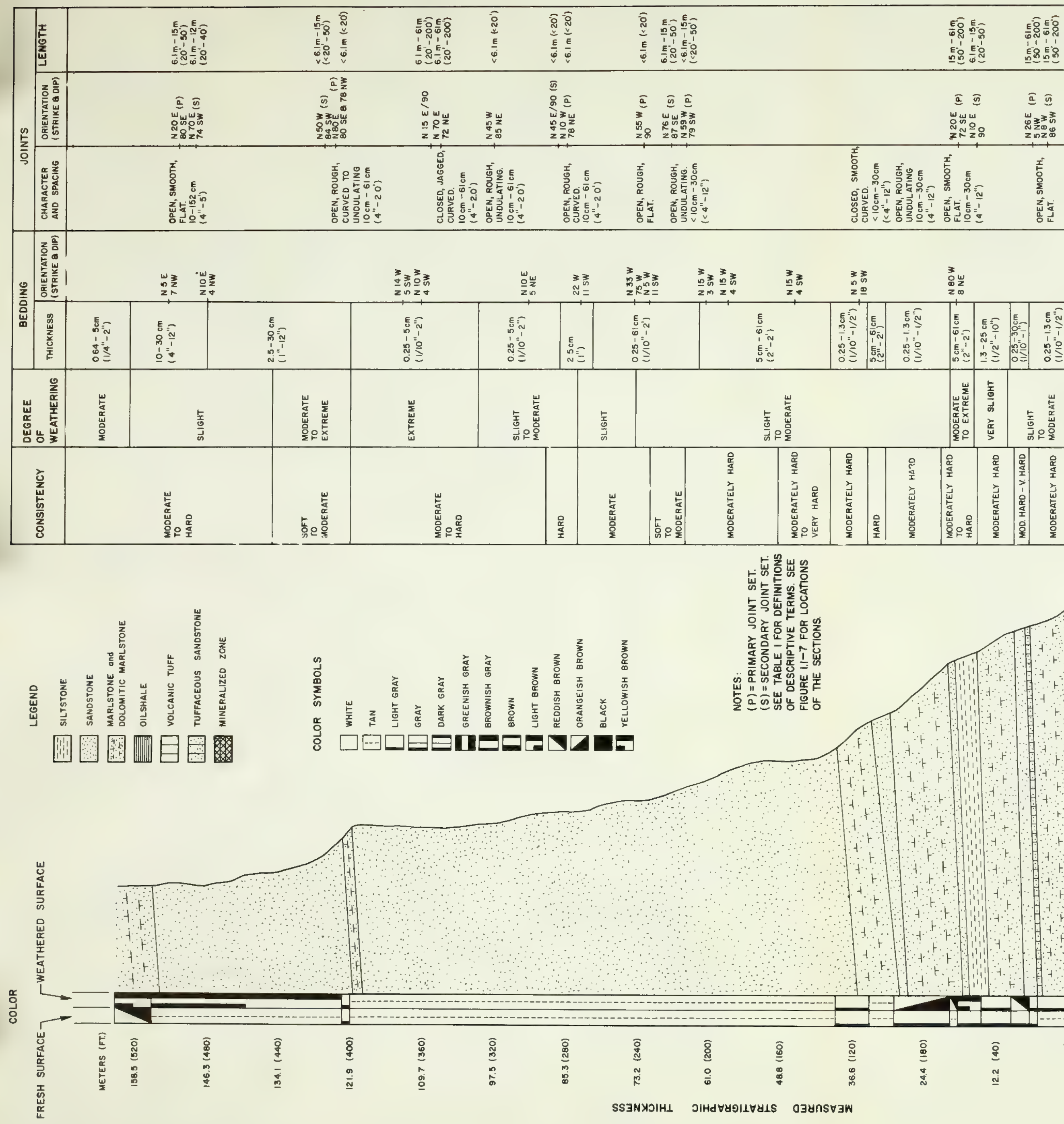
CONTOUR INTERVAL IN PERCENT OF TOTAL SAMPLE

0-5
5-10
10-15
15-20
20-25

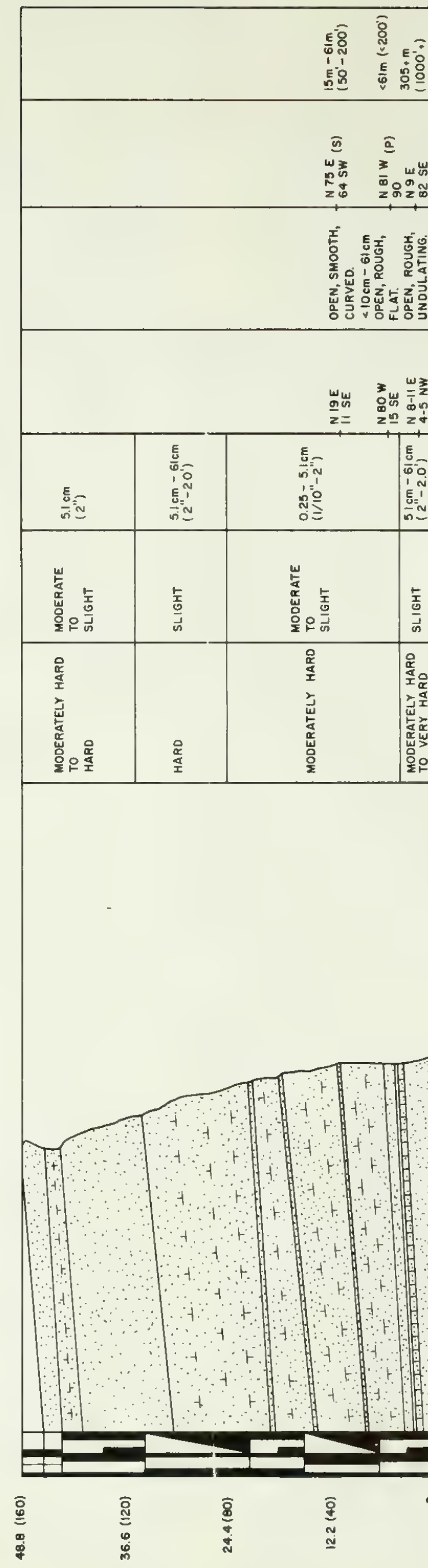


COUNT DIAGRAM OF POINTS REPRESENTING JOINT PLANE
ORIENTATIONS, SEC. 31,32 & 33, T10S, R24E

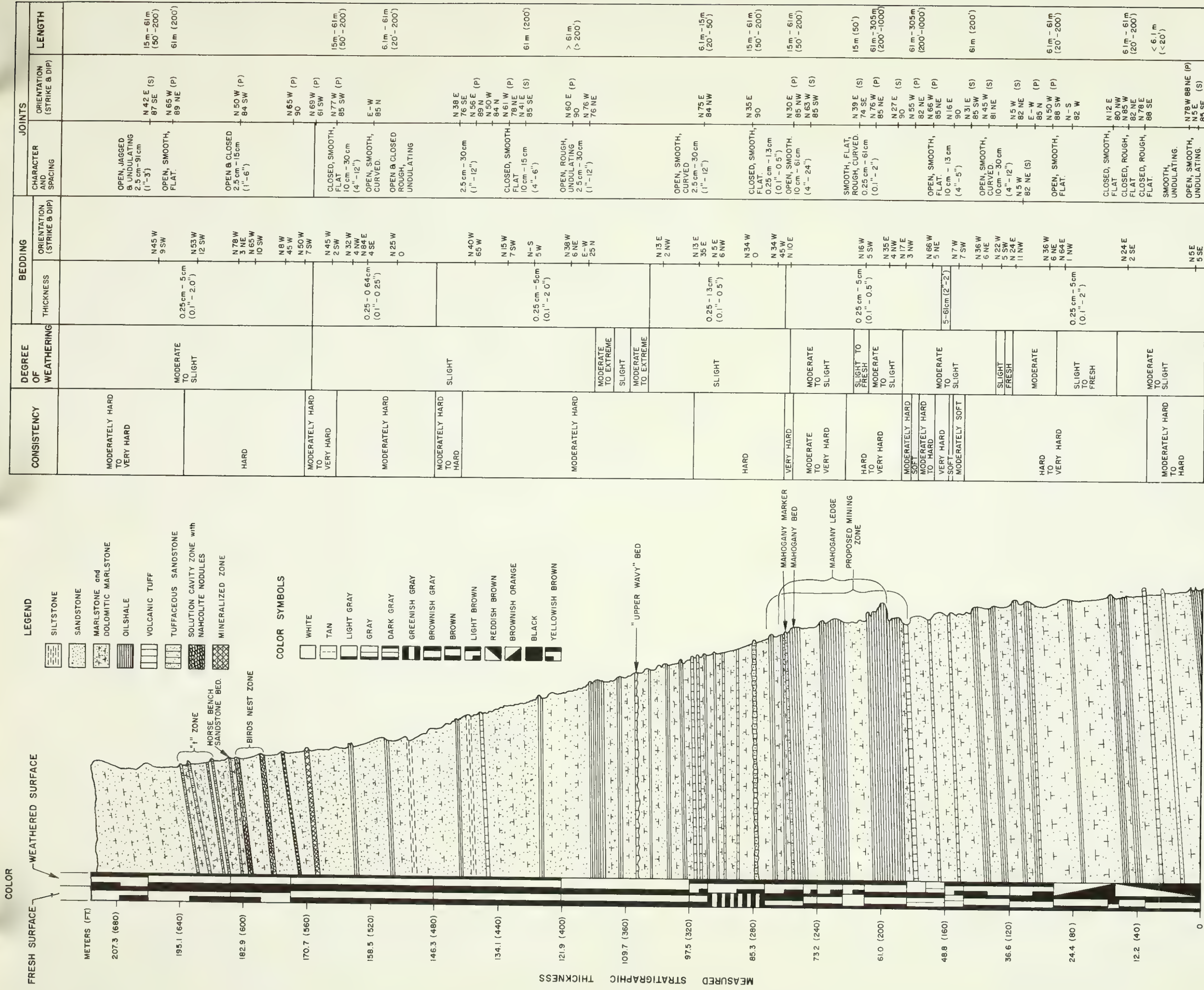
FIGURE V-13



MEASURED STRATIGRAPHIC SECTION OF THE UINTA FORMATION (SECTION 1-C).



MEASURED STRATIGRAPHIC SECTION NEAR THE CONTACT BETWEEN THE GREEN RIVER AND UINTA FORMATIONS (SECTION 1-B).



NOTES: (P) = PRIMARY JOINT SET.

(S) = SECONDARY JOINT SET.

SEE GEOLOGIC MAP OF TRACTS Ua - Ub FOR THE LOCATION OF THE SECTION.

SEE TABLE I FOR DEFINITIONS OF THE TERMS USED TO DESCRIBE THE PHYSICAL

MEASURED STRATIGRAPHIC SECTION OF THE UPPER PORTION OF THE PARACHUTE CREEK MEMBER OF THE GREEN RIVER FORMATION (SECTION 1-A), CHARTER

TABLE V- 11

INTERVALS OF CORES ON WHICH ASSAY AND ROCK MECHANICS
TESTS WERE PERFORMEDHole Number
Interval (in feet) *

<u>P-1</u>	<u>P-2</u>	<u>P-3</u>	<u>P-4</u>	<u>X-1</u>	<u>X-2</u>	<u>X-3</u>
676-677	751-752	731-732	672.6 - 673.6	978-979	607-608	438-439
677-678	752-753	732-733	673.6 - 674.6	979-980	608-609	439-440
678-679	753-754	733-734	674.6 - 675.4	980-981	609-610	440-441
685-686	763-764	740-741	680.7 - 681.7	987-988	616-617	441-442
686-687	764-765	741-742	681.7 - 682.7	988-989	617-618	442-443
687-688	765-766	742-743	682.7 - 683.7	989-990	618-619	443-444
697-698	772-773	752-753	692.6 - 693.6	996-997	625-626	450-451
698-699	773-774	753-754	693.6 - 694.6	997-998	626-627	451-452
699-700	774-775	754-755	694.6 - 695.6	998-999	627-628	452-453
706-707	781-782	761-762	701.6 - 702.6	1005-1006	637-638	459-460
707-708	782-783	762-763	702.6 - 703.6	1006-1007	638-639	460-461
708-709	783-784	763-764	703.6 - 704.6	1007-1008	639-640	461-462
715-716	793-794	770-771	710.5 - 711.5	1014-1015	646-647	471-472
716-717	794-795	771-772	711.5 - 712.5	1015-1016	647-648	472-473
717-718	795-796	772-773	712.5 - 713.5	1016-1017	648-649	473-474
727-728	802-803	782-783	722.7 - 723.7	1023-1024	655-656	489-490
728-729	803-804	783-784	723.7 - 724.7	1024-1025	656-657	490-491
729-730	804-805	784-785	724.7 - 725.7	1025-1026	657-658	491-492
736-737	811-812	791-792	731.7 - 732.7	1032-1033	667-668	498-499
737-738	812-813	792-793	732.7 - 733.7	1033-1034	668-669	499-500
738-739	813-814	793-794	733.7 - 734.8	1034-1035	669-670	500-501
745-746	823-824	800-801	740.7 - 741.7	1041-1042	676-677	507-508
746-747	824-825	801-802	741.7 - 742.7	1042-1043	677-678	508-509
747-748	825-826	802-803	742.7 - 743.7	1043-1044	678-679	509-510
757-758	832-833	812-813	752.7 - 753.7	1050-1051	685-686	513-514
758-759	833-834	813-814	753.7 - 754.7	1051-1052	686-687	514-515
759-760	834-835	814-815	754.7 - 755.7	1052-1053	687-688	515-516
766-767	841-842	821-822	761.7 - 762.7	1059-1060	691-692	522-523
767-768	842-843	822-823	762.7 - 763.7	1060-1061	692-693	523-524
768-769	843-844	823-824	763.7 - 764.7	1061-1062	693-694	524-525
775-776	853-854	830-831				
776-777	854-855	831-832				
777-778	855-856	832-833				
787-788	862-863	842-843				
788-789	863-864	843-844				
789-790	864-865	844-845				
796-797	871-872	851-852				
797-798	872-873	852-853				
798-799	873-874	853-854				
805-806	883-884	860-861				
806-807	884-885	861-862				
807-808	885-886	862-863				
817-818						
818-819						
819-820						

TABLE V-11 (Cont.)

Hole Number
Interval (in feet)*

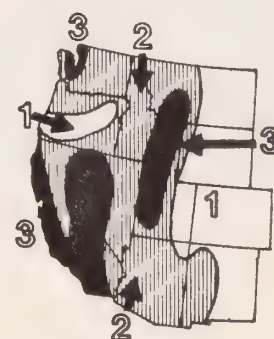
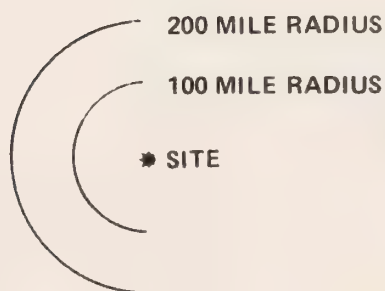
<u>X-4</u>	<u>X-5</u>	<u>X-6</u>	<u>X-9</u>	<u>X-10</u>	<u>X-11</u>
810-811	789-790	651-652	933-934	942-943	835-836
811-812	790-791	652-653	934-935	943-944	836-837
812-813	791-792	653-654	935-936	944-945	837-838
819-820	798-799	663-664	942-943	954-955	847-848
820-821	799-800	664-665	943-944	955-956	848-849
821-822	800-801	665-666	944-945	956-957	849-850
831-832	807-808	672-673	951-952	963-964	856-857
832-833	808-809	673-674	952-953	964-965	857-858
833-834	809-810	674-675	953-954	965-966	858-859
840-841	819-820	681-682	963-964	972-973	865-866
841-842	820-821	682-683	964-965	973-974	866-867
842-843	821-822	683-684	965-966	974-975	867-868
849-850	828-829	690-691	972-973	981-982	877-878
850-851	829-830	691-692	973-974	982-983	878-879
851-852	830-831	692-693	974-975	983-984	879-880
861-862	837-838	702-703	981-982	993-994	886-887
862-863	838-839	703-704	982-983	994-995	887-888
863-864	839-840	704-705	983-984	995-996	888-889
870-871	846-847	711-712	993-994	1002-1003	895-896
871-872	847-848	712-713	994-995	1003-1004	896-897
872-873	848-849	713-714	995-996	1004-1005	897-898
879-880	855-856	720-721	1002-1003	1011-1012	907-908
880-881	856-857	721-722	1003-1004	1012-1013	908-909
881-882	857-858	722-723	1004-1005	1013-1014	909-910
891-892	864-865	732-734	1011-1012	1023-1024	916-917
892-893	865-866	734-735	1012-1013	1024-1025	917-918
893-894	866-867	741-742	1031-1014	1025-1026	918-919
900-901	873-874	742-743	1023-1024	1032-1033	925-926
901-902	874-875	743-744	1024-1025	1033-1034	926-927
902-903	875-876		1025-1026	1034-1035	927-928

*To convert to meters multiply by 0.305



LEGEND

- INTENSITY V-VII
(except California)
- INTENSITY VII-VIII
- INTENSITY VIII-IX
- ⊙ INTENSITY IX-X
- ⊙ INTENSITY X-XII



SOURCE: Earthquake History of the United States, National Oceanic and Atmospheric Administration Environmental Data Service, ed. by Coffman and Von Hake, 1973

- 1-MINOR
- ▨ 2-MODERATE
- 3-MAJOR

**EARTHQUAKES THROUGH 1970 AND SEISMIC RISK MAP
FOR WESTERN UNITED STATES**

FIGURE V-16



Landslides and Rockfalls

Ancient landslides are evident along many of the steep cut-banks of the White River. There is also evidence of recent debris flows within steep drainages and rockfalls along sharp ridges. Areas particularly susceptible to rockfalls are shown in dark gray or black on the site slope gradient map (Figure V-17). Severe thunderstorms and accompanying flash floods are the primary forces causing landslides and debris flows.

f. Mineral Resources

Economically important deposits of minerals within the Uinta Basin are shown on Figure V-18. These minerals are described in detail in the FYEBR.

3. INTERPRETATION AND CONCLUSIONS

Tracts U-a and U-b lie within the Uinta Basin, a prehistoric depositional lake basin. The land within the tracts is a gently northsloping plateau with steep-walled canyons containing ephemeral streams subject to flash flooding. Intertributary divides are capped by resistant rock strata, creating mesas, cuestras, and hogbacks. The major canyons and divides within the tracts are north-south trending and oriented perpendicular to the White River, which lies north of the tracts.

The White River is the only perennial stream flowing through the tracts. Evacuation Creek is an intermittant stream, and the remaining watercourses are ephemeral. The drainage pattern on the tracts varies with surface lithology and is influenced by joint patterns.

The bedrock that outcrops in the region includes the Wasatch, Green River, Uinta, and Duchesne River formations. These formations reflect different stages in the development of Lake Uinta and the Uinta Basin.

The strata at the site generally dip less than 5° north or northwest. There are no known faults and only minor folds. One set of primary and three sets of secondary near-vertical joints occur throughout the site area.

The tracts lie within the lowest seismic risk zone. Occasional landslides and debris flows occur as a result of severe thunderstorms and accompanying flash floods.

LEGEND

0-6% (0-3°) :
LEVEL TO GENTLY SLOPING

7-14% (3-6°) :
UNDULATING TO ROLLING

15-30% (7-13°) :
ROLLING TO HILLY

31-50% (14-22°) :
HILLY TO STEEP

≥ 51% (≥ 23°) :
STEEP AND VERY STEEP



SLOPE GRADIENT MAP - TRACTS U-a & U-b

LEGEND

GILSONITE VEINS

OIL FIELD

GAS FIELD

BITUMINOUS SANDSTONES OR TAR SANDS

TOTAL THICKNESS OF OIL-SHALE BEDS, IN FEET

NEAR SURFACE, MEDIUM AND HIGH VOLATILE BITUMINOUS COAL SEAMS AT LEAST 14 INCHES THICK

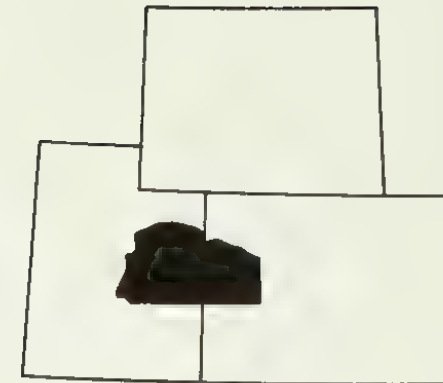
URANIUM DEPOSIT CONTAINING LESS THAN 1000 TONS OF ORE WITH AT LEAST 0.1 PERCENT OF U_3O_8

GYPSUM OUTCROP

NAHCOLITE DEPOSIT, SUBSURFACE LIMITS UNCERTAIN

SOURCES OF INFORMATION

- 1) OIL AND GAS FIELDS FROM RITZMA, 1972
- 2) OIL-SHALE THICKNESS FROM CASHION, 1964
- 3) BITUMINOUS SANDSTONE LOCATIONS FROM CURTIS 1972
- 4) COAL FIELDS FROM AVERITT, 1972
- 5) LOCATIONS OF URANIUM DEPOSITS FROM BUTLER, 1972
- 6) GYPSUM AND NAHCOLITE AREAS FROM HITE, 1972
- 7) GILSONITE VEINS FROM W.L. STOKES & J.H. MASDEN 1961



INDEX MAP



MINERAL RESOURCES OF THE UINTA BASIN

4. EVALUATION OF BASELINE PROGRAM

The geology baseline program is completed and is in compliance with the Federal Oil Shale Lease Stipulations, the Partial Exploration Program Supplement, and the Conditions of Approval of the plan and supplement. Data were compiled and analyzed in order to determine the suitability of mine facility locations and to establish a baseline for monitoring possible mining-related affects on the environment. Included are both site-specific and regional data.

The geology baseline program has adequately defined regional and site geologic conditions. In addition, the data are sufficient for determining suitabilities of mine facility locations and for establishing a baseline for monitoring of geology-related impacts such as subsidence, mass wasting, and physiographic alteration during mine development.

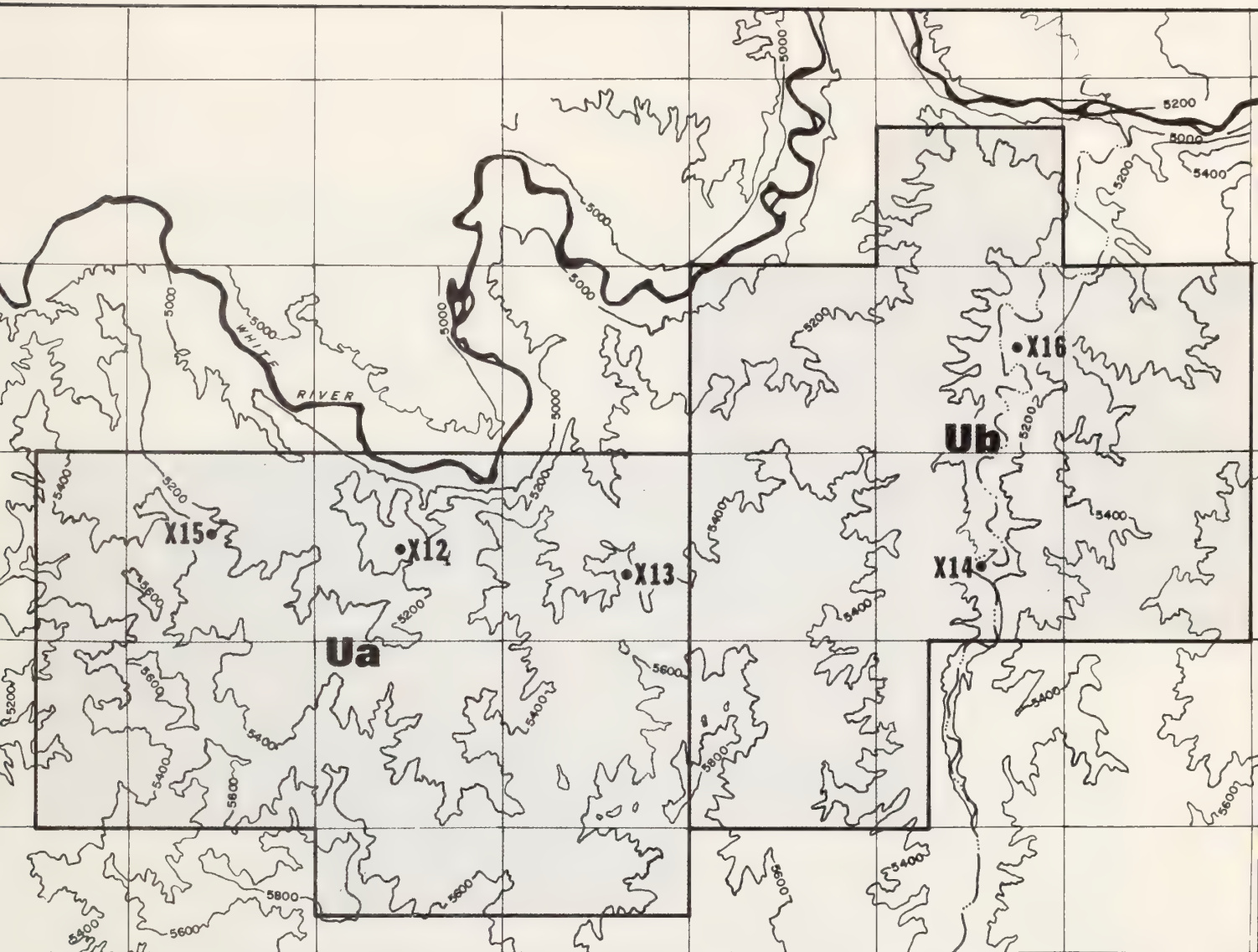
C. GEOLOGIC EXPLORATION PROGRAM

The original geologic element of the Partial Exploration Plan was approved in November 1974, and the field work was completed in January 1975. Eleven vertical drill and core holes were completed under this element of the plan. The primary purpose of the drilling program was to supplement the existing subsurface hydrologic data, to provide additional resource evaluation data, and to collect core and cutting samples for geochemical analysis. The results of this initial program are reported either in the First Year Environmental Baseline Report or under separate cover to the Area Oil Shale Supervisor (AOSS) and will not be repeated here.

A supplemental exploration program was designed based upon some data gaps in the initial program. This program was approved by the AOSS in February 1976 and will be the topic of discussion in this report. The WRSP, through their contractor, the Cleveland Cliffs Iron Company (CCIC), has reported the results of this program to the AOSS, and the data will be summarized in this report.

1. METHODOLOGY

The initial exploration program was supplemented by the drilling of five additional drill and core holes. These are labeled X-12 through X-16 on Figure V-19. Two of the holes, X-14 and X-15, were slant-drilled in a northeast direction at an inclination of about 30°. These holes were



LEGEND

- GEOLOGIC EXPLORATION CORE HOLE
- ♣ SLANT-DRILLED CORE HOLE



DRILL HOLE SITES

SUPPLEMENTAL GEOLOGIC EXPLORATION PROGRAM

FIGURE V-19

continuously cored and were designed to provide data regarding the density and orientation of fracturing with depth. The other three holes were rotary drilled to 18 m (60 ft) above the mining zone to 27.5 m (90 ft) below the mining zone and were designed to provide additional resource evaluation and mining-zone data. Hole X-13 was drilled as an investigation hole for future shaft sinking. All holes were monitored for the quality of water discharged under the conditions of NPDES permits.

2. SUMMARY OF RESULTS

In addition to the trace metal analyses determinations made of core samples during the initial program, core was selected from hole X-13 in the intervals 301.34 m to 304.70 m (988 ft to 999 ft), 305.61 m to 327.88 m (1002 ft to 1075 ft), and 312.93 m to 323.0 m (1026 ft to 1059 ft). The amount of antimony, arsenic, boron, cadmium, fluoride, mercury, and selenium in these samples was determined and reported in a December 1976 report from CCIC to the WRSP entitled White River Shale Project Supplemental Exploration Project Report, as follows:

	Interval 301.32-304.70 m	Interval 305.61-327.88 m	Interval 312.93-323.0 m
Antimony	0.16 ppm	0.26 ppm	0.30 ppm
Arsenic	9.00 ppm	10.00 ppm	12.00 ppm
Boron	15.00 ppm	12.20 ppm	10.50 ppm
Cadmium	0.10 ppm	0.15 ppm	0.13 ppm
Fluoride	1012.00 ppm	1250.00 ppm	1325.00 ppm
Mercury	0.10 ppm	0.06 ppm	0.12 ppm
Selenium	0.15 ppm	.30 ppm	0.17 ppm

3. INTERPRETATION AND CONCLUSIONS

Using t-test techniques, CCIC statistically compared the rock chemistry collected during the initial exploration program with that collected from the supplemental program and concluded --

In 95% of the cases, any further testing would not produce significantly different results and it is recommended that the data on hand be accepted as representative of the general concentrations to be found across Tracts U-a and U-b.

The chemistry and statistical results have been filed with the AOSS.

Tests for nahcolite were determined from core samples when the mineral was identified in the core. Of the 13 holes drilled for the exploration program, 4 contained nahcolite intercepts ranging from 18.3 cm to 0.69 m (0.60 ft to 2.25 ft) and are confined to an interval that lies from 2.7 m to 7.02 m (12 ft to 23 ft) below the Mahogany Marker. The results of the nahcolite testing program prompted CCIC to report --

The best that can be said is that the distribution of nahcolite in the Mahogany Zone at U-a and U-b appears to be intermittent and the overall occurrence may be described as scarce. As a consequence, the economic importance of the mineral, as compared to the total shale oil potential of the proposed mining zone, is relatively insignificant.

Based upon the results of the slant-hole drilling, CCIC reported --

In general, the physical competency displayed by the core as it was removed from the core barrel was very good. In particular, inclined fractures are nearly absent and only a few, relatively short vertical fractures were observed.

Gas-monitoring equipment was installed on holes X-12 and X-13 (which are now shut in and fitted with pressure gages), and flow and temperature devices were installed on X-1, X-5, X-9, and X-11. Supplemental grab samples and flow records are being collected from the last four.

4. EVALUATION OF BASELINE PROGRAM

Not applicable

Glossary

GLOSSARY

Alkali soil: a soil with so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of total exchangeable bases), or both, that growth of most crop plants is severely restricted.

Alluvial fan: a low, outspread, relatively flat to gently sloping mass of loose rock material shaped like an open fan and deposited by a stream at the place where it emerges from a narrow, steep valley onto a plain or broad valley.

Alluvium: unconsolidated sediments deposited during comparatively recent geologic time by a stream or other body of running water.

Aquic: a reducing soil regime. Some soil horizons of an aquic soil are saturated at times with water while dissolved oxygen is present.

Arch: a broad, regional scale upfold of strata.

Aridisols: soils that are generally dry and have light-colored or thin surface horizons with well-expressed lime horizons (Calcic horizon) or sodic horizons (natic horizon).

Available water holding capacity: the capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed in inches of water per inch of soil.

Calcareous soil: a soil that contains calcium carbonate or lime. The following terms are used to describe calcareous soils and the amounts of calcium carbonate equivalent the soil contains: slightly calcareous - 1 to 3 percent calcium carbonate equivalent. moderately calcareous - 3 tp 15 percent calcium carbonate equivalent. strongly calcareous - 15 to 40 percent calcium carbonate equivalent.

Calciorthids: orthids that have had much lime in the parent materials or added in dust. The low rainfall is unable to remove the lime completely from the surface soil. The only horizons normally present are the ochric surface and a calcic horizon whose upper boundary generally is at a depth of less than 50 cm (20 inches).

Channery soil: a soil containing 15 to 20 percent thin, flat sandstone, siltstone, limestone or shale fragments up to 6 inches along the longer axis. A very channery soil is one that contains more than 50 percent channery fragments.

Colluvium: a loose, heterogeneous mass of soil material or rock fragments deposited chiefly by mass wasting, at the base of a steep slope.

Color, soil: according to the Munsell Notation System, determined by degrees of three variables--hue, value, and chroma. For example, a notation of 10YR6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4. The color name is light yellowish brown.

Conglomerate: a coarse-grained sedimentary rock of rounded fragments larger than 2 mm in diameter set in a fine-grained matrix of sand, silt or any of the common material cementing materials. The coarse grains are fragments of pre-existing rocks.

Cretaceous Period: the final period of the Mesozoic Era. It is thought to have covered the span of time between 136 and 65 million years ago.

Cuesta: a symmetrical ridge with a long gentle slope corresponding to the dip of a resistant bed and a steep slope on the cut edge of the beds.

Debris flow: a mass movement involving rapid flowage of debris, especially a high-density mudflow resulting from heavy rain.

Dendritic drainage pattern: a drainage pattern in which the streams branch irregularly in all directions and at almost any angle resembling the branching of veins in a maple leaf.

Entisols: soils that lack distinct horizons.

Eocene Epoch: an early epoch of the Tertiary Period of the Cenozoic Era. It is thought to have covered the span of time between 58 and 36 million years ago.

Ephemeral stream: a stream or portion of a stream that flows briefly only in direct response to precipitation in the immediate area.

Fault: a surface or zone of rock fracture along which there has been displacement.

First-order limits: maximum allowable discrepancy for high precision elevation determinations.

Flaggy soil: contains relatively thin fragments (6 to 15 inches long) of sandstone, limestone, slate or shale. A single piece is a flagstone.

Fluvents: mostly brownish soils that formed in recent water-deposited sediments, mainly on flood plains, fans and deltas.

Fluvial: of or pertaining to rivers or streams.

Formation: the basic rock-stratigraphic unit in the local classification of rocks consisting of a body of rock generally characterized by some degree of internal homogeneity or distinction features.

Frigid: having a mean annual soil temperature of less than 8°C (47°F).

Geomorphology: the study of the origin and development of landforms.

Hogback: a sharp-crested ridge formed by differential erosion of a resistant bed of steeply dipping rocks.

Horizon, soil: a layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes.

O horizon - the layer of organic matter on the surface of some mineral soils. This layer consists of decaying plant residues.

A horizon - the mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and, therefore, is marked by the accumulation of humus. The horizon may have lost soluble salts, clay and/or sesquioxides.

Infiltration: the inflow of water into earth materials.

Interfluve: the area between streams, especially the upland between adjacent stream valleys.

Joint: a fracture in a rock. A joint differs from a fault in lacking displacements on opposite sides of the fracture.

Liquefaction: the transformation of loosely packed sediment into a fluid mass preliminary to movement of a turbidity current by subaqueous slumping or sliding.

Liquid limit: the moisture content at which a soil passes from a plastic to a liquid state.

Lithic: a lithic contact is a boundary between soil and continuous, coherent underlying material (sandstone and shale bed-rock). A lithic soil is diagnostic at the subgroup level if it is within 50 cm (20 inches) of the surface of the mineral soil.

Lithologic: of or pertaining to rocks.

Loamy-skeletal: rock fragments make up 35 percent or more of the soil by volume, enough fine earth to fill interstices larger than 1 mm; the fraction finer than 2 mm is loamy as defined for the loamy particle-size class.

Mahogany zone: a descriptive name for the zone of commercially important oil shale.

Mixed: the soil has less than 40 percent of any one mineral other than quartz or feldspars.

Nahcolite: a white hydrocarbon mineral containing sodium.

Natrargids: argids that have a natric horizon. The natric horizon is a special kind of argillic horizon that has 15 percent or more saturation with exchangeable sodium in some horizon within 40 cm (16 inches) of the surface.

Nutrients: chemical elements, ions, or compounds necessary for biological growth.

Oil shale: a marlstone which is rich in kerogen (distillable hydrocarbons).

Paleocene Epoch: the earliest epoch of the Tertiary Period of the Cenozoic Era. It is thought to have covered the span of time between 65 and 58 million years ago.

Pedon, soil: a volume of soil, one meter on each side and two meters deep, or to rock or other inhibitory layers.

Percolation: the movement of water through the earth.

Permeability, soil: that quality of the soil that enables it to transmit water or air. Some of the terms used to describe permeability are as follows: Slow - 0.06 to 0.2 inches per hour. Moderate - 0.60 to 2.0 inches per hour. Rapid - 6.0 to 10.0 inches per hour.

pH value: a numerical means for designating acidity and alkalinity in soils. A pH value of 7.0 indicates precise neutrality, a higher value, alkalinity, a lower value, acidity. Degrees of acidity or alkalinity are: medium acid--5.6 to 6.0 pH; slightly acid--6.1 to 6.5 pH; neutral--6.6 to 7.3 pH; mildly alkaline--7.4 to 7.8 pH; moderately alkaline--7.9 to 8.4 pH; and strongly alkaline--8.5 to 9.0 pH.

Physiography: the descriptive study of landforms.

Plastic limit: the moisture content at which a soil changes from a semisolid to a plastic state.

Platy structure: soil structure in the form of thin flat sheets of soil.

Quaternary Period: the second period of the Cenozoic Era. It is thought to have covered the last two or three million years.

Saline soil: contains soluble salts in amounts that impair growth of plants.

Soil families: classification based on properties important to the growth of plants or to engineering.

Strata: layers or bodies of homogeneous or gradational sedimentary material of any thickness visually separable from each other by distinct changes in sedimentary material.

Stratigraphic: of or pertaining to the sequence of rock strata of the Earth's crust.

Structure, soil: the arrangement of primary soil particles into compound particles that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil properties. The principle forms of soil structure are: platy (laminated), prismatic (vertical axis of aggregates larger than horizontal), columnar (prism with rounded tips), blocky (angular or subangular), or granular. Structureless soils are single grain or massive.

Subsidence: a local mass movement that involves principally the gradual downward settling or sinking of the solid Earth's surface with little or no horizontal motion and that does not occur along a free surface.

Texture, soil: the relative proportions of sand, silt and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay and clay. The sand, loamy sand and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Torrifluvents: fluvents of arid climates that are not flooded frequently or for long periods. They have a torric moisture regime (soils are hot and dry during the summer).

Torriorthent: soils with a torric moisture regime that have more than 35 percent rock fragments (by volume) in some sub-horizon above the lithic contact.

Typic: an adjective used for the subgroup that is thought to typify the great group. For example, the Torrifluvents that typify the central concept of the great group are called Typic Torrifluvents.

Ustic: a soil of limited moisture, but the moisture is present at the time when conditions are suitable for plant growth.

Ustifluvents: fluvents with an ustic moisture regime. These soils are on river flood plains.

References

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VI HISTORIC & SCIENTIFIC RESOURCES



VI. CULTURAL (HISTORICAL AND PRE-HISTORICAL) AND PALEONTOLOGICAL RESOURCES

The historical and scientific resources program was completed in July 1975 and a final report was submitted to the AOSS for approval. Investigations were conducted to locate and identify important cultural (historical and prehistoric) and paleontological resources on Tracts U-a and U-b and a 1.6-km (1-mi) perimeter to meet the lease stipulations and federal and state antiquities laws. During the investigations, which consisted of on-ground surveys and archival reviews, 36 cultural sites and 39 paleontological sites were inventoried and evaluated. Detailed site-location data are omitted from this document to prevent unauthorized collecting from the sites.

The cultural resources investigations were conducted by Dr. David B. Madsen, Antiquities Section, Utah Historical Society (UHS). The paleontological resource investigations were conducted by Dr. Wade E. Miller, Department of Geology and Zoology, Brigham Young University (BYU).

A. CULTURAL RESOURCES

1. METHODOLOGY

The methodology used in the cultural resources investigation consisted of on-going surveys, artifact analysis, archival reviews, and contacts with local amateur archeologists. The methods were consistent with current historical and archeological investigation techniques.

The entire study area was walked and visually inspected by a four-to-five member field team. The area was traversed by the team, with each person spaced 6 m to 30 m (20 ft to 100 ft) apart and walking in a zigzag pattern except where prevented by topography or vegetation. The field investigation took a total of 67 days during four periods between July 15, 1974, and May 27, 1975.

The sites located were photographed, recorded on standard site-survey forms, and plotted on USGS 7.5-minute topographic maps. Each prehistoric site was given a number in accordance with the Smithsonian Trinominal System. Representative artifacts were collected from the surface for laboratory analysis. The collected artifacts were described, drawn,

and compared with published reports of similar artifacts from the Great Basin, Uinta Basin, and Great Plains to identify potential cultural affiliations of the sites. The collected artifacts have been stored with the UHS and will be available for further research. The historical sites were located by the archeological field crew and inspected by the UHS historical subconsultants to evaluate their importance.

2. SUMMARY OF RESULTS

The 36 cultural sites located during the investigation consisted of 10 historical and 32 prehistoric components (six of the sites have both historical and prehistoric components). Seven of the sites are on the tracts and 27 sites are within the 1.6-km perimeter. Three sites--42 Un 365, 42 Un 403, and 42 Um 405--are outside the study area.

a. History

The study area has been isolated from the mainstream of regional historical events. From the first recorded historic contact in 1776 until mineral exploration and development began in the late nineteenth century, no significant historic activities took place in or around the study area. More significant activities have occurred in other portions of the Uinta Basin, however. These activities can be divided into four periods: native American, early European exploration and trade, agrarian settlement, and mineral development.

At the time of historic contact, the Uinta Basin was the homeland of the Ute Indians, who subsisted by hunting small game and collecting wild plant foods. Some of the Ute bands to the east and west had acquired horses from the Spanish by this time. These bands had a lifestyle similar to that of the more well-known Plains Indians. The various bands maintained close relations through intermarriage and ceremonial activities.

The arrival of the first Europeans marked the beginning of a series of drastic changes in the Indians' lifestyle. The first European contact was from the south, when Spanish explorers and traders attempted to extend their sphere of influence from Mexico. Reports of trade between the Spaniards and the Utes date back as early as 1712. This trade steadily increased despite laws passed in 1775 forbidding it. The first recorded visit to the area was made by the

Escalante expedition in 1776, which intensified the pressure for trading with the Indians (Figure VI-1). During the 1820s non-native American use of the Uinta Basin intensified as a result of the influx of French and American fur trappers and traders from the east and south. The first year-round white settlement, Fort Robidoux, was established as a trading post in 1838 and soon became the central meeting point for travelers, traders, and trappers. The trading era ended because of the Mexican War and declining demand for furs.

The historical event that had the greatest impact in shaping the present economy and culture of the Uinta Basin was the colonization of the area by Mormon settlers in the late nineteenth century. The Mormons did not enter and explore the Uinta Basin until 1861, although the Wasatch Front further west had been settled by the first wave of Mormon settlers 14 years earlier. It soon became apparent that the agrarian settlers and the Utes were in direct competition for the limited resources available along the Wasatch Front. Several skirmishes erupted between settlers and the Ute Indians. Following the Walker War along the Wasatch Front in 1854, the Uintah Reservation was established in the Uinta Basin at the request of the settlers. The Utes refused to move to the reservation, which led eventually to the Black Hawk War (1864 to 1869), in which the Indians were defeated and finally removed to the reservation.

The decade of the 1870s was marked by the establishment of an Ashley Valley settlement, which later became Vernal. Several communities--Naples, Maeser, Jensen, and Hallsville--developed in the surrounding area, and in 1886 a stake of the Church of Jesus Christ of Latter Day Saints was founded in Vernal. During this period, conflicts between Uncompahgre Utes and white settlers in western Colorado led to transfer of the Indians to the Uintah Reservation and the creation in 1881 of the Uncompahgre Reservation. Fort Thornburgh was established to protect the area but was abandoned three years later. Fort Duchesne, founded in 1886 eventually became a permanent settlement.

The second most important influence on Uinta Basin history was the discovery and exploitation of the area's rich mineral resources. The discovery of gilsonite in the late 1800s led to mounting pressure for opening of the reservations lands to development. Finally, in 1895, the practice began of allotting 160-acre homesteads to the Utes so that other parts of the reservation could be opened for mineral development. The two reservations were combined into what is now the Uintah and Ouray Reservation, and in 1905 President Roosevelt opened the rest of the reservation lands for settlement.



MAP OF UINTA BASIN BEFORE 1900

FIGURE VI-1



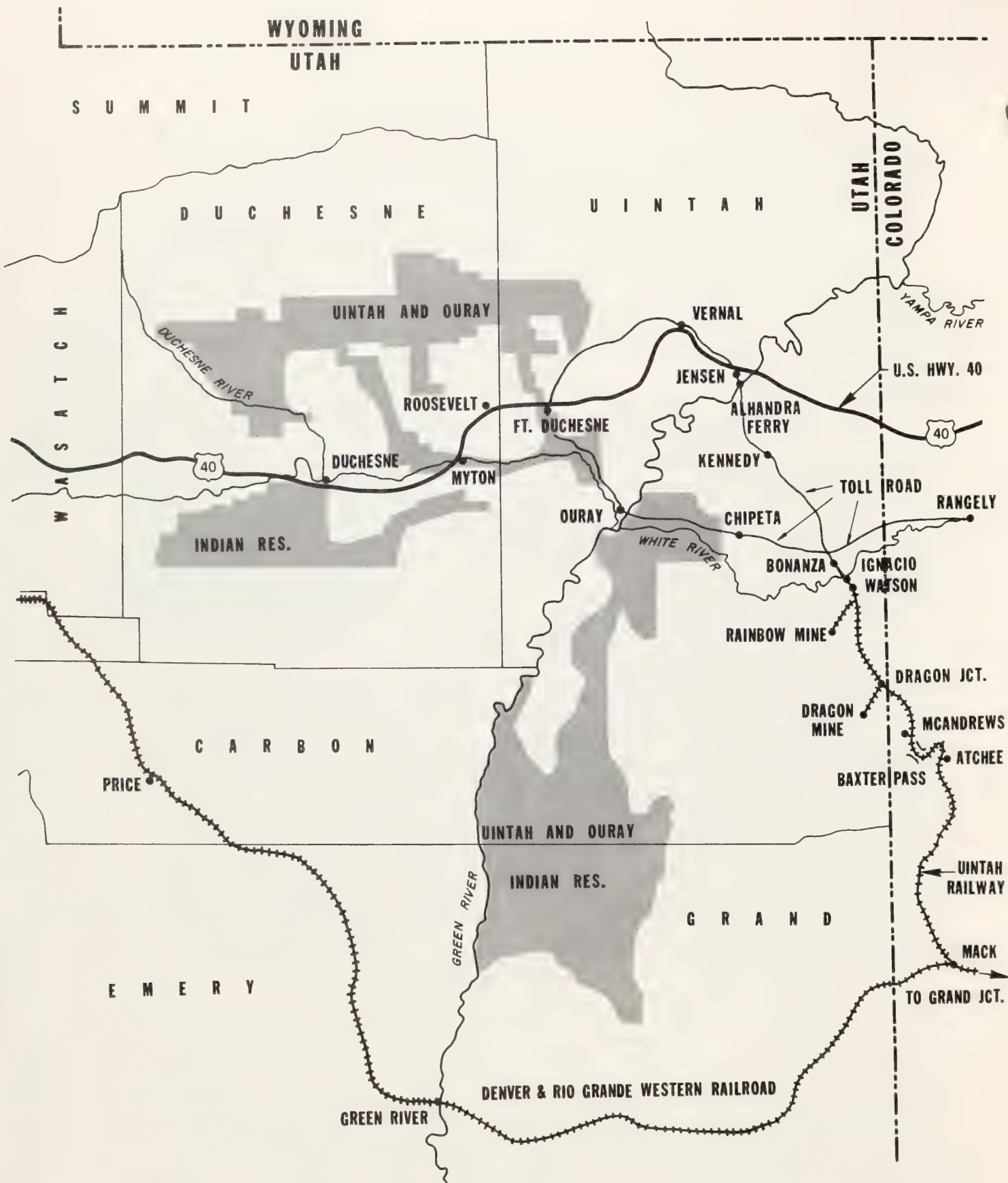
The rapid development of gilsonite mining in the basin and the opening of several small mines in Colorado led to the organization of the Uintah Railway to transport the ore over the Book Cliff Mountains from Mack, Colorado, to connect with the Denver & Rio Grande Western Railroad (Figure VI-2). Following completion of the railroad in 1904, a toll road was built connecting the northern terminus of the railroad at Dragon with Vernal, with a series of stage stops in between. The opening of the reservation lands precipitated a new wave of settlement, and in 1933 additional land was withdrawn from the Uintah Reservation under the Taylor Grazing Act.

Although gilsonite activities in the Uinta Basin had declined by the 1930s (with the exception of the American Gilsonite mine at Bonanza), energy-related development has continued to be important in the economic development of the area. Oil and gas exploration and production have been major activities since the 1950s, and interest has recently turned to extraction of oil from tar sands and oil shale, especially on Tracts U-a and U-b south of Bonanza. Full-scale commercial development of these resources could signify the beginning of another major period of development in the Uinta Basin.

The historic sites in the area consist of the Ignacio Stage Stop (Figure VI-3), four homestead cabins, and five recent camp sites. Only two (the recent camp sites) are located on the tracts. The stage stop located east of Utah State Highway 45 on the south side of the White River was built in 1905 and was the first stop along the Uintah Railway toll road to Vernal, Utah. The remaining structures, now in poor condition, are representative of the architecture of the late frontier period. The homestead cabins were built during the early 1920s and are now dilapidated. None have been occupied by historically important people. The campsites, identified as the recent temporary encampments of sheepherders or hunting parties, are considered historically insignificant by the investigators.

b. Prehistory

The known prehistoric cultural resources in the region indicate that the Uinta Basin has been occupied by various groups for the last 10,000 years, including Paleo-Indian "big game" hunters, Archaic and Basketmaker II hunter-gatherers, Fremont agriculturalists, late prehistoric Northwest Plains hunter-gatherers, and protohistoric Numic (shoshonean linguistic group) hunter-gatherers. Although there have been numerous archeological surveys and excavations, knowledge



MAP OF UINTA BASIN, 1930'S

FIGURE VI-2



FIGURE VI-3 IGNACIO STAGE STOP

of these groups is limited in comparison with what is known of other areas, because much of the research was done before the development of the radiocarbon dating technique and other methods of dating artifacts. More recent research has concentrated on only a few of these groups and on limited areas of the Uinta Basin. The sites located during the investigation were so disturbed, that the prehistoric inhabitants in the study area could be only tentatively identified. Most of the sites showed evidence of unauthorized artifact collecting in the form of surface collecting and digging, both of which disturb potential functional and chronological information that may be obtained during a surface investigation. Interpretations were therefore limited only to establishing the presence or absence of some of the previously mentioned prehistoric cultures. The prehistoric sites are described on Table VI-1.

The Thompson collection (site 42 Un 377) unequivocally establishes the presence of Archaic hunter-gatherers in the area. The presence of McKean points (Figure VI-4) suggests that initial occupation in the study area occurred between 4800 B.P. and 3300 B.P. Subsistence activities apparently centered around hunting, as indicated by the charred bone refuse unearthed at the site. The virtual absence of milling stones at 42 Un 377 and most of the recorded sites suggests that floral resources were not extensively exploited at the riverine encampments.

The cultural affiliation of the remainder of the sites is difficult to assess. The small projectile points (Figure VI-5) from sites 42 Un 365, 42 Un 367, 42 Un 370, 42 Un 376, 42 Un 377, 42 Un 379, and 42 Un 405 indicate the use of the bow and arrow. The corner-notched varieties are similar to types associated with Northwest Plains hunter-gatherers (Kehoe 1966), eastern Plains agriculturalists (Johnson 1974), the Uncompahgre Complex (Wormington and Lister 1956), Pueblo I in the Anasazi area (Brew 1946), and various Fremont complexes (Marwitt 1970). This indicates a temporal range of 1450 B.P. to 850 B.P. The side-notched types replaced the corner-notched points on the northwest Plains (Kehoe 1966) and are associated with Pueblo II and III complexes in the Anasazi area (Morris 1939; Brew 1946). Their distribution in the Fremont area is restricted to the Great Salt Lake and Uinta variants. The temporal range in the study area is probably 1000 B.P. to 650 B.P. Of these various cultures, only the northwest Plains and Uncompahgre were aceramic (lacking pottery), and therefore the absence of pottery at sites yielding the small points suggests Plains or Uncompahgre affiliation. The only evidence of Anasazi cultures in the study area is the Tusayan Corrugated pottery recovered from site 42 Un 401. Mesa

TABLE VI-1

DESCRIPTION OF THE PREHISTORIC SITES

Site Number	Site Type	Cultural Affiliations	Cultural Materials
On Tracts			
324	Rock Shelter	?	point fragment, chipping debris, bone, charcoal, trash deposits
372	Open	Archaic?	biface, utilized flakes
373*	Open	Archaic?	utilized flakes, fire-cracked river cobbles, chipping debris
406	Open	?	biface, flaked cobbles
407	Rock Shelter	Historic	trash
408	Open	?	biface, utilized flakes, chipping debris
409*	Rock Shelter	?	bifaces, utilized flakes, hammerstone.
		Historic	encampment debris
Off Tracts			
42 Un 118*	Rock Shelter	?	chipping debris, mat fragments, corn cobs, burned bone
355*	Rock Shelter	Archaic	point fragment, utilized flakes, chipping debris
356*	Open	?	worked flakes, chipping debris
357*	Open	Archaic	projectile point, chipping debris
358*	Open	Late Prehistoric	projectile point
		Numic?	
365*	Rock Shelter	Late Prehistoric	projectile point, possible granary
		Historic	trash
366	Rock Shelter	Archaic?	biface, projectile point, chipping debris, pictograph, charcoal, burned bone
367*	Rock Shelter	Late Prehistoric	various projectile points, bifaces, utilized flakes, cores
368*	Open	Archaic?	bifaces, utilized flakes
369*	Open	Archaic?	bifaces, worked flakes, chipping debris

TABLE VI-I (Cont.)

Site Number	Site Type	Cultural Affiliations	Cultural Materials
42 Un			
370*	Open	Archaic?	projectile point, bifaces, utilized flakes, hammerstones, fire-blackened cobbles
371*	Open	Late Prehistoric	etched stone tablet, utilized flake
374*	Open	Archaic?	biface, utilized flake, fire-cracked cobbles
375*	Open	Archaic?	point fragment, biface, utilized flakes
376*	Open	Archaic?	projectile points, utilized flakes, chipping debris
377*	Open	Late Prehistoric	point fragment, biface, utilized flakes, Thompson artifact collection
378*	Open	Archaic?	biface, utilized flakes, chipping debris
379*	Open	?	projectile point, utilized flakes, chipping debris, Tipi Ring(?)
380*	Open	Historic	trash
381*	Rock Shelter	Archaic	projectile point
401*	Open	?	fire-blackened cobbles, charcoal
402*	Open	Late Prehistoric	pot sherds, mano, metate, hammerstone, bifaces, utilized flakes, chipping debris, Ignacio Stage Stop
403*	Rock Shelter	Historic	bifaces, utilized flakes, cores, flakes cobbles
	Isolated	?	prehistoric pictographs
	pictographs	Historic	writing
404*	Rock Shelter	?	projectile point
405*	Open	Plains?	structures(?), fire pits(?), steatite pipe, hammerstone, projectile points, drill, bifaces, utilized flakes

NOTES: Historic components, except 401, Ignacio Stage Stop, consist of trash from recent sheepherder or hunter camps.

*indicates sites that could provide further information.
See discussions in section VI.A.3 and VI.A.4



FIGURE VI-4 MC KEAN PROJECTILE POINTS



42 UN 365



42 UN 405



42 UN 376



42 UN 405

SIDE-NOTCHED



42 UN 367

CORNER-NOTCHED



42 UN 370



42 UN 379



42 UN 376

STEMMED

0 1 2 3 CM.

FIGURE VI-5 SMALL PROJECTILE POINT SERIES

Verde ceramics have been reported by Breternitz (1970) at Dinosaur National Monument, but this is the first reported occurrence of Kayenta series ceramics in the Uinta Basin. Breternitz interprets the Mesa Verdean ceramics as "trade ware" rather than as an indication of Anasazi occupation. The same interpretation is probably appropriate here, although it is also possible that the Kayenta sherds were transported to the site by white travelers.

Sites 42 Un 118 and 42 Un 366 are potentially the Basketmaker II period. The Basketmaker II level of technology is defined as the absence of ceramics, use of atlatl, and the cultivation of maize. Site 42 Un 118 has yielded numerous corn cobs but no pottery. No pottery was recovered from 42 Un 355, and the red ochre pictographs are quite similar to those associated with Basketmaker II sites in northeastern Arizona. Neither site yielded diagnostic lithic material. The Basketmaker II assignment is admittedly conjectural, and controlled excavation would be required to support or refute this claim.

No definite evidence of Fremont occupancy was found in the survey area. The only examples of Uinta Gray pottery have been found a few miles east of the study area. This indicates that contrary to published opinion, Fremont agriculturalists may not have been the predominant cultural entity in the Uinta Basin during the late (post 1500 B.P.) prehistoric period. The same conclusion is suggested by the Dinosaur National Monument data (Breternitz 1970), since only about 5% of the sites contained Fremont pottery types.

Rock art located during the investigation consists of pictographs, petroglyphs, and an etched stone tablet. Site 42 Un 366 has three pictographs and two petroglyphs. The pictographs are painted designs (red ochre) of a "horned Fremont" figure, a snake-like figure, and one unidentified figure. The petroglyphs are pecked or incised horse and mountain-sheep designs. Site 42 Un 403 is a big-horn sheep petroglyph (Figure VI 6). The etched stone tablet (Figure VI-7) was found at 42 Un 371. The designs on the tablet are geometric and anthropomorphic.

The cultural affiliations of the rock art are difficult to determine for two reasons. Previous investigators (Gunnerson 1957, 1969; Morss 1931; Schaafsma 1971; Sharrock 1966) have identified similar designs as Fremont; however, these designs also occur in Montana and Arizona, where there is no evidence of Fremont occupation. Rock art can rarely be associated with a particular culture, since they usually do not occur in a stratified, or datable, context. Further academic research is needed to establish the cultural affiliations and purposes of these and other Uinta Basin rock art designs.



FIGURE VI-6 BIG HORN PETROGLYPH (42 UN 403)



0 1 2 3 4 CENTIMETERS

FIGURE VI-7 ETCHED STONE TABLET (42UN371).

3. INTERPRETATION AND CONCLUSIONS

The cultural resources located by the UHS investigation indicate the study area has been occupied intermittently from approximately 5000 years ago through recent times. With the exception of the historical sites and some prehistoric sites, the cultural periods and affiliations of most sites could not be determined.

The only historic site identified is the Ignacio Stage Stop because of its association with the historical events in the region and as being representative of late pioneer architecture. Ignacio Stage Stop is not on the tracts. The site was being considered for nomination to NRHP and URHS. The nomination was not completed because written consent was not obtained from the landowner as required by Utah Executive Order dated March 24, 1976. This executive order has subsequently been rescinded by new legislation (H.B. 283) enacted in April 1977. Under the new law, written consent is no longer required; however, the landowner must be notified in writing so that he may comment on the eligibility of the site for inclusion in the NRHP and URHS and be informed of the tax implications of such a nomination as provided by the Tax Reform Act of 1976 (PL 94-455, section 2124). In addition, the new Utah law now protects cultural properties affected by state projects as well as those on state lands.

The "Criteria of Adverse Effect" as required by 36 CFR Part 800.4(d) was initiated by UDSH for the prehistoric sites. Their determination was that the White River Shale Project (WRSP) would have no adverse effect on the on-tract sites if the mitigation measures described in the Detailed Development Plan (DDP) are implemented. It was also determined that UDSH would not pursue the nomination of the WRSP study area as an archeological district, since this responsibility rests with the Utah Bureau of Land Management. Individually, only a few of the sites meet criteria for NRHP eligibility; however, as a group, the sites may have the potential for providing further information on Uinta Basin prehistory.

4. EVALUATION OF BASELINE PROGRAM

The investigations conducted for the baseline program have located and evaluated the cultural resources within the study area as required by the lease stipulations and antiquities laws and regulations (specifically 36 CFR Part 800).

An exhaustive evaluation of the importance of these resources, except for the historic resources, was not possible because of the following reasons:

1. The poor surface conditions of most the prehistoric sites prevented more definitive identifications of cultural affiliations and importance.
2. Controlled surface and subsurface testing of the sites, which may have provided this information for evaluative purposes was not allowed by the sub-consultant's antiquities permit.
3. An adequate synthesis of Uinta Basin prehistory that would provide a basis of comparison for the data is not yet available.

B. PALEONTOLOGICAL RESOURCES

1. METHODOLOGY

The paleontological investigation consisted of archival reviews, a field survey, and fossil identification. All fieldwork was conducted by Dr. Miller and qualified graduate and undergraduate students. Dr. Stephen Wood, an entomologist with BYU, was consulted to identify the fossil insect specimens.

Before the field survey began, regional paleontological and geological documents were reviewed to determine potentially fossiliferous areas. The material included geological reports and maps and paleontological literature pertaining to the Uinta Basin.

The fieldwork conducted between July 1974 and May 1975, consisted of a preliminary inspection of the study area and a full field survey. The site was first inspected to determine the logistical requirements for the field survey. The field survey consisted of inspections of the baseline monitoring sites, the new access roads, and then the remaining study area, section by section. The entire study area was walked and visually examined, with particular attention given to outcrops of geologic formations. The sites located were plotted on USGS 7.5-minute topographic maps. The type and the condition of a fossil's geologic formation and the location data were recorded and photographs were taken. Each fossil locality was given a field number.

Fossils that could not be identified in the field were removed and taken to BYU. Each specimen was removed from its sandstone matrix and identified by comparison with descriptions of previously collected specimens. These specimens are stored at BYU pending any further work. Dr. Wood accompanied Dr. Miller to the study area to inspect the located fossil insect sites. Dr. Wood identified the insect types and determined the state of preservation and the scientific value of the fossil specimens.

2. SUMMARY OF RESULTS

Fossils were discovered in most of the project area in both the Green River and Uinta formations of the Eocene Epoch. Leaves, petrified wood, insect fossils, and fish fossils were found in the Green River Formation, and fossils of petrified wood, turtle bone and shell, crocodile, and bron-
tothere were found in the Uinta Formation. The fossil types and formations are listed on Table VI-2.

The concentration of fossils in the paleontological sites ranges from dense to sparse, and the state of preservation ranges from poor to excellent. Each paleontological site is described on Table VI-3. Eighteen of the 39 sites are on the tracts and three sites (12, 19, and 32) are outside the study area.

The plant fossils most easily identified were the leaves of angiosperms, or flowering plants (Figure VI-8). The leaf fossils consisted of carbonized compressions and a few imprints. Petrified wood occurs throughout the study area, but generic identification was generally impossible.

The best represented insect fossils were from the order Diptera (Figure VI-9). Six families--Bibionidae, Syrphidae, Muscidae, Stratiomyidae, Oestridae, and Tephritidae--were identified. Of these families, the only generic identifications possible were *Musca* (common fly), *Hypoderma* and *Lithohypoderma* (bot flies), *Lithophysa* (soldier fly), and *Tipula* (crane fly), all from the last four families. Fossil insects from the other three orders were poorly preserved. Most of the fossil insects were larval forms.

The only fossil fish were scales identified as *Lepidosteus* (gar pike). Bone fragments were found but were not identifiable. Reptilian fossils were represented by *Allognathosuchus* (crocodile) and various turtle bone and shell fragments that could not be identified.

TABLE VI-2

FOSSIL TYPES LOCATED DURING THE PALEONTOLOGICAL INVESTIGATION

<u>Common Name</u>	<u>Genus or Family Name</u>	<u>Formation of Occurrence</u>	
		Middle Eocene Green River Fm.	Late Eocene Uinta Fm.
PLANTS:			
Laurel	<u>Umbellularia</u>	X	
Poplar	<u>Populus</u>	X	
Willow	<u>Salix</u>	X	
Sycamore	<u>Platanus</u>	X	
INVERTEBRATES:			
March Flies	<u>Bibionidae</u>	X	
Flower Flies	<u>Syrphidae</u>	X	
Common Fly	<u>Musca</u>	X	
Bot Fly	<u>Lithohypoderma</u>	X	
Bot Fly	<u>Hypoderma</u>	X	
Soldier Fly	<u>Lithophysa</u>	X	
Crane Fly	<u>Tipula</u>	X	
Dragonfly	<u>Sympetrum</u>	X	
VERTEBRATES:			
Gar Pike	<u>Lepidosteus</u>	X	
Alligator	<u>Allognathosuchus</u>		X
Brontothere (large extinct mammal)	<u>Paleosyops</u>		X
"	<u>Eotitanops</u>		X
"	<u>Telmatherium</u>		X
"	<u>Dolichorhinus</u>		X
"	<u>Metarhinus</u>		X

TABLE VI-3
DESCRIPTION OF THE PALEONTOLOGICAL SITES

<u>Site Number</u>	<u>Fossil Types</u>	<u>Geological Formations</u>	<u>Scientific Value*</u>
<u>On Tracts</u>			
1	Unidentifiable plant debris	Uinta	1
2	" " "	"	1
3	Fragmental plant remains	Green River	2
4	Unidentifiable plant debris	Lower Uinta, Upper Green River	1
5	Fragmental plants, some complete leaves	Green River	3
6	Unidentifiable plant debris	Lower Uinta, Upper Green River	1
8	Fragmental plants, some complete leaves	Green River	3
9	Fish scales, leaves	" "	4
20	Turtle shell & bone plant fragments	Uinta	4
23	Turtle shell fragments,	"	2
24	Brontothere teeth, turtle shell	"	6
28	Brontothere bone, petrified wood	"	5
29	Petrified wood	"	2
30	Turtle shell fragments	"	2
32	Unidentifiable bone fragments	"	2
34	Fish scales	Green River	2
35	Wood fragments	Uinta	1

TABLE VI-3 (Cont.)

<u>Site Number</u>	<u>Fossil Types</u>	<u>Geological Formations</u>	<u>Scientific Value*</u>
<u>On Tracts</u>			
36	Wood fragments	Uinta	1
<u>Off Tracts</u>			
7	Insects, leaves	Green River	4
10	Unidentifiable wood fragments	Uinta	1
11	Insects	Green River	4
12	"	" "	5
13	Wood fragments	Uinta	1
14	Insects, plant fragments,	Green River	4
15 a,b,c	Insects, plant fragments	" "	3
16	Insects, plant fragments seeds	" "	4
17	Insects	" "	5
18	Plant fragments, some complete leaves	Uinta	3
19	Plant fragments, some complete leaves	Lower Uinta, Upper Green River	3
21	Some petrified wood	Uinta	2
22	Brontothere bones, turtle shell	"	6
25	Petrified wood	"	2
26	Brontothere teeth, turtle shell fragments	"	6
27	Petrified wood	"	2
31	Brontothere teeth & bones	"	6

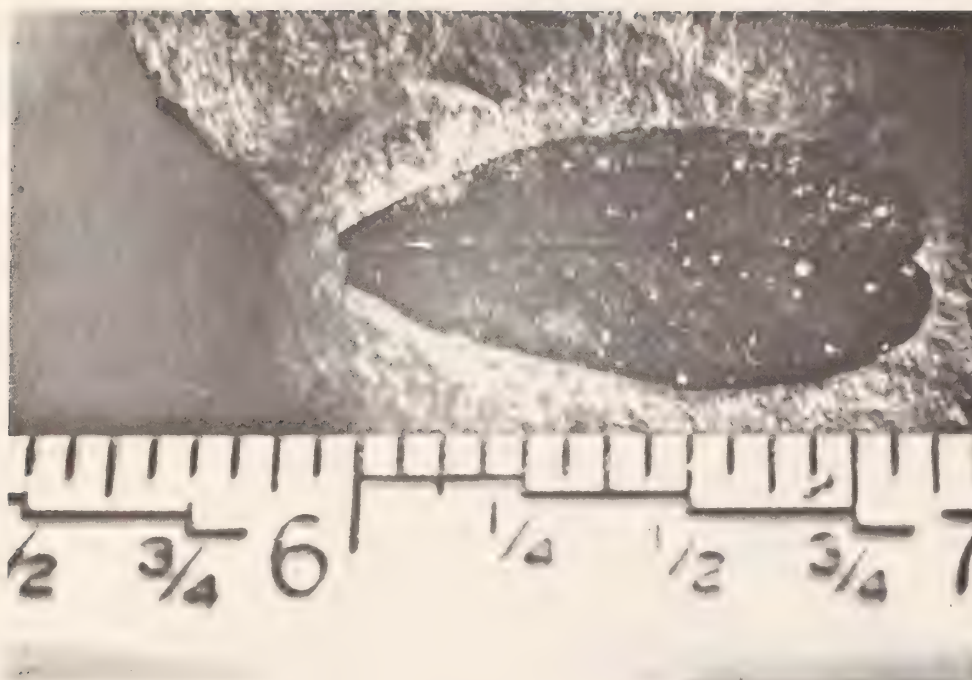
TABLE IV-3 (Cont.)

<u>Site Number</u>	<u>Fossil Types</u>	<u>Geological Formations</u>	<u>Scientific Value*</u>
<u>Off Tracts</u>			
33	Petrified wood	Uinta	2
37	Fragmental plants, some complete leaves	"	3
38	Fragmental plants, some complete leaves	"	3
39	Brontothere teeth & bones alligator teeth, turtle shell	"	6

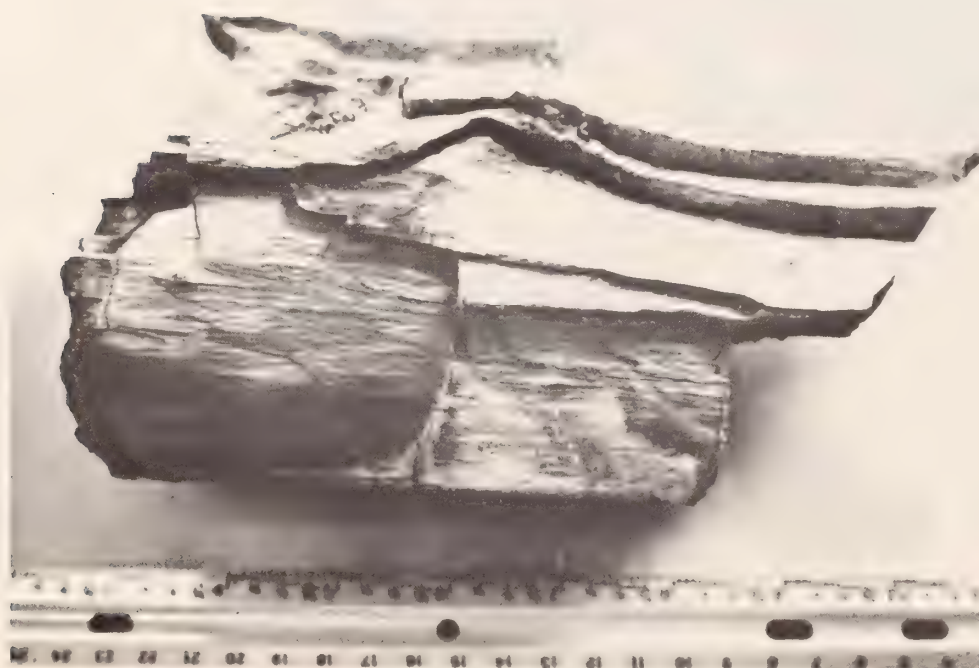
* The fossil sites have been assigned a level of scientific value by the paleontological subconsultant. These are as follows:

1. Insignificant
2. Minor
3. Minor-Moderate
4. Moderate
5. Moderate-Major
6. Major

These levels are intended to identify the potential amount of information that could be recovered from the sites through further scientific investigations.



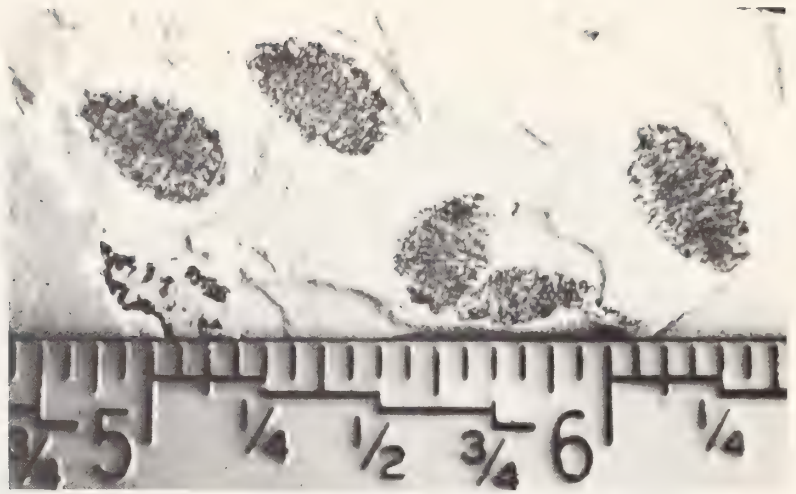
ELM LEAF



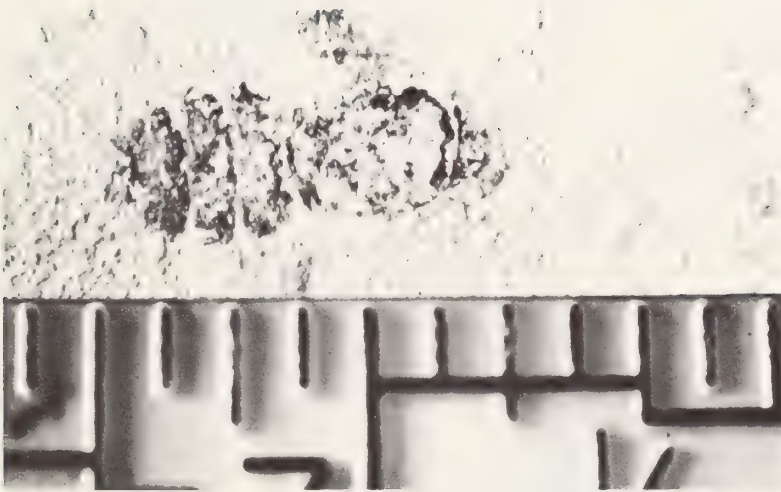
PETRIFIED WOOD, SPECIES INDETERMINATE

FIGURE VI-8 FOSSIL PLANTS

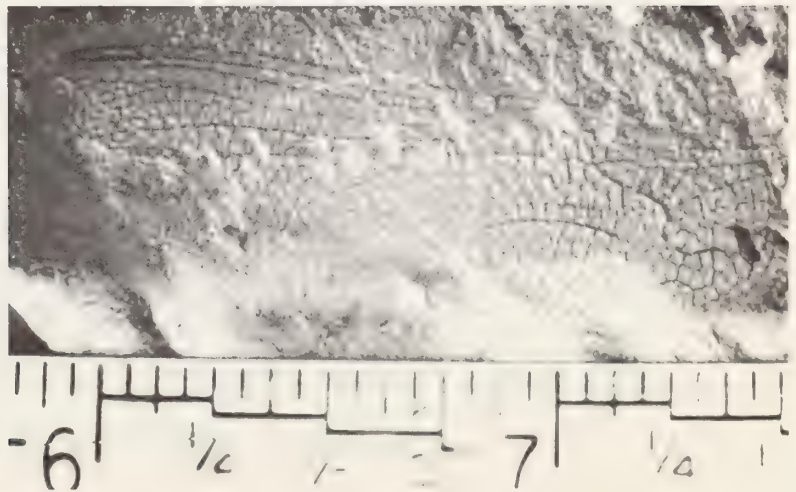
VI-23



LARVAL FLIES, HYPODERMA



ADULT FLY, LITHOPHYSA



DRAGON FLY WING, DYSAGRION OR SYMETRON

The only mammalian fossils discovered were five genera of brontothere (order Perrissodactyla), large mammals now extinct that are taxonomically related to the horse and the rhinoceros (Figure VI-10). These included Paleosyops, Eotitanops, Telematherium, Dolichorimus, and Metharhinus. Some unidentified bone fragments may belong to a similar mammal type known as a uintathere (order Dioncerata). Although not located during this investigation, other mammal fossils may be found in subsurface deposits.

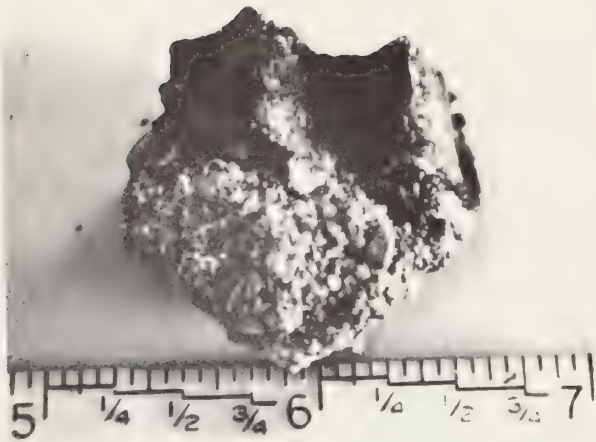
3. INTERPRETATION AND CONCLUSIONS

While not specifically defined in current federal and state antiquities laws, paleontological resources are provided the same protection as cultural resources. Federal policy has been established by various Department of Interior solicitors' opinions issued by the Solicitor General based on interpretations of the Antiquities Act of 1906 (43 CFR Part 3). This protection, however, is currently limited only to vertebrate fossils, with paleobotanical and invertebrate fossils rarely protected unless they have exceptional scientific value.

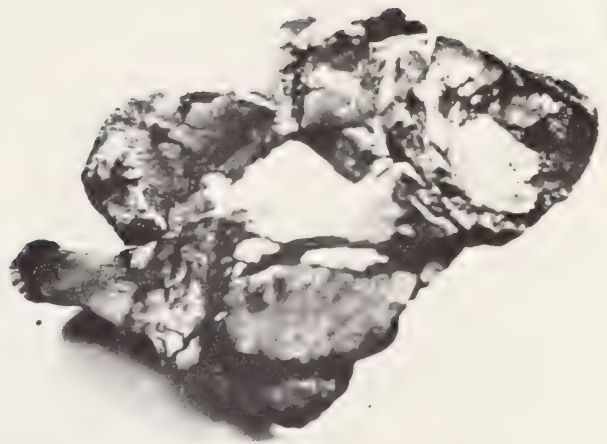
All fossils have scientific value, but to differing degrees. Plant fossils are useful only as general indicators of geologic time and as indicators of past climatic conditions. This has been true for plant fossils from the Uinta Basin, especially those from the Green River Formation. Invertebrate fossils are usually better time indicators than are plant fossils, and are also useful in interpreting paleoenvironments. Vertebrate fossils, especially those of mammals, are very useful as time indicators. They are also useful in determining past climatic and environmental conditions for a given time and place. Mammal fossils have been important in determining that the Green River Formation is a series of lake beds and the Uinta Formation primarily stream deposits.

Fossil mammals give the most precise dating in Cenozoic age strata. Radiometric dating is very limited in sedimentary rocks. A set of mammal ages was worked out for the Cenozoic of North America (similar sets based on different mammals have or are being worked out for other continents). These are subdivisions of time that are chronologically more refined than those based on other means. The North American mammal ages for the latter half of the Eocene are based on mammalian fossils from the Uinta Basin.

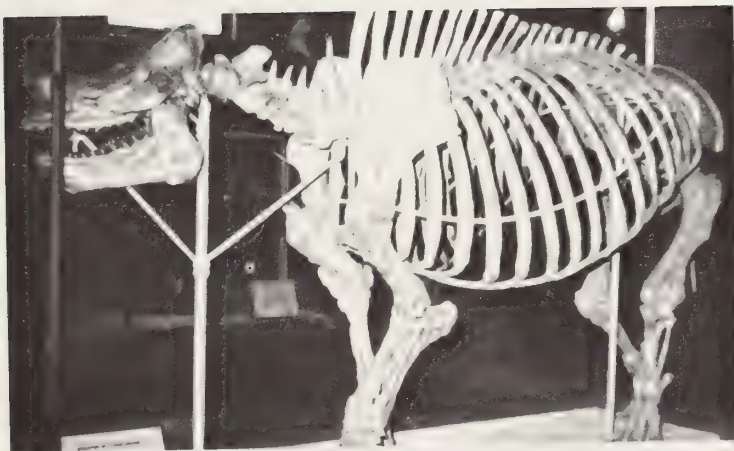
Twenty-one sites located during the present investigation were found to be significant in terms of indicating changes



BRONTOTHERE TOOTH, PALEOSYOPS



BRONTOTHERE PELVIS, SPECIES INDETERMINATE



RECONSTRUCTED BRONTOTHERE, TITANOTHERE
(AT AMERICAN MUSEUM OF NATURAL HISTORY)



BRONTOTHERE RESTORATION

FIGURE VI-10 BRONTOTHERES

in the environment. The fossils that have been identified show clearly the environmental changes that occurred from the deposition of the Green River Formation to that of the Uinta Formation. High concentrations of insect larvae and numerous reed imprints are highly indicative of lake deposits that are typical of the Green River Formation. The overlying Uinta Formation includes stream-dwelling brontotheres, which reflect an environmental change from the underlying lake deposits.

Although the most well-preserved fossil-plant localities in the Green River Formation have been found outside the project area, subsurface deposits of fossil plants may occur on the tracts. Fossil insects, which have been found in high concentrations, have not been as extensively studied as other groups in paleontology. Information from these fossils is potentially very important to studies of paleoecology, paleoclimatology, and evolution.

The presence of several types of brontotheres is considered significant, especially because of their abundance and good state of preservation. Because they occur throughout a few hundred meters of strata, it is possible that evolutionary changes can be detected. Previous work in this area was incomplete, and additional academic studies are needed, especially since other mammals are probably present in this part of the Uinta Formation.

The present paleontological survey has provided additional fossil specimens of scientific value that otherwise might not have been found for some time, and it is certain that future academic studies of the important fossil sites will provide valuable specimens. According to the paleontological subconsultant, the fossils discovered within the tract area were not significant enough to be included in the National Registry of Fossil Sites. However, significant fossil sites discovered in areas outside the boundaries of Tracts U-a and U-b should be protected. These sites all included specimens of brontotheres, an extinct relative of the rhinoceros.

4. EVALUATION OF BASELINE PROGRAM

Potentially important paleontological resources in the study area have been identified as required by the lease stipulations and current laws and regulations. Also identified are the further scientific research potentials of each site. The information is sufficient to identify specific adverse or beneficial impacts and to develop appropriate mitigation measures.

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VII

AESTHETICS



VII. AESTHETICS

Aesthetic values were assessed to establish a baseline of existing conditions as a guide in reclaiming the area after mining. Physical, biological, and human-interest features were evaluated in terms of their positive and negative uniqueness, and were documented photographically prior to data collection and monitoring.

A. METHODOLOGY

The characteristic landscape of an area is identified by the overall impression created by the different visual features of the landscape. The four elements that compete for dominance in any landscape are form, line, color, and texture. Variations and deviations to the characteristic landscape are caused by natural and man-made objects that attract the viewer's attention from the normal landscape.

For this study, aesthetic resources were defined in terms of landscape units. A landscape unit is an area of land with common distinguishing visual characteristics in the landform, rock formations, water forms, and vegetative patterns.

B. SUMMARY OF RESULTS

The boundary landforms around the Uinta Basin are the dominant aesthetic resources of the region. The most accessible of these are the Uinta Mountains, the Book Cliffs, the Wasatch Plateau, Flaming Gorge National Recreation Area, Dinosaur National Monument, and the Green River. The landscapes are diverse, from the glacier-scoured Uinta Mountains to river-cut Split Mountain in Dinosaur National Monument. The area is known as "red rock country," indicating the dominant color. Atmospheric conditions that influence the perception of aesthetic resources in the region are dust, daily extremes in temperature, and dryness.

Tracts U-a and U-b and a 1.6-km (1-mi) border area were divided into mappable landscape units. The perceptual input from natural and man-made aesthetic resources were compared for each unit. Three landscape units were defined: the ridgetop-basin unit, the canyon unit, and the White River unit. These units will be considered separately. The three units are shown on Figure VII-1.

a. The Ridgetop-Basin Landscape Unit

The ridgetop-basin complex includes areas in which an observer above the surrounding landscape can see for great distances (see figures VII-2 and VII-3). The most distinct views are from the ridges serving as drainage divides between Asphalt Wash and Southam Canyon and Southam Canyon and Evacuation Creek and from the ridges overlooking tributary basins to the White River. These areas afford spectacular panoramic views that reveal the contrast between the brown-to-buff Uinta Formation and the underlying Green River Formation and its numerous strata, which give a horizontal linear pattern to the light-gray unit. The views are so distant that the aesthetic experience is primarily visual. The views are highlighted at sunrise, when individual buttes and ridge walls are illuminated, and at sunset, when the canyons are in shadow.

In contrast, the setting on the ridgetops is dominated by unusual micro-landforms, such as lichen, ancient ripple marks, precipitation cusps in rock, the honeycombed appearance of some calcareous rock, and seedling pinyon trees (see figures VII-4 and VII-5). Numerous rock pinnacles, water pockets, balanced rocks, and rock windows are the most prominent unique geologic features. These include Castle Rock and Duck Rock, which are accessible from the main improved dirt road that runs from Ignacio Bridge to Southam Canyon. The environment on the ridgetops is usually quiet, and the visibility is usually excellent. Water pockets form in small rock depressions on the mesa tops and give added diversity to the landscape. Most areas in this unit are accessible by short hikes from the improved direct roads or by driving directly over a drainage divide like the road from Southam Canyon to Asphalt Wash. Lizards, snakes, mourning doves, deer, cottontail rabbits, and antelope ground squirrels are often seen, as are soaring raptors such as red-tailed hawks in summer and golden eagles in winter, spring, and summer.

b. The Canyon Landscape Unit

The canyon areas include Evacuation Creek, lower Southam Canyon, Asphalt Wash, and all steep-walled tributaries to these drainages and to the White River. Because the water-land interface is such a dominant element in the White River canyon, this area will be considered separately. The canyon landscape unit is characterized by enclosed views enhanced by geologic detail, micro-changes in vegetation, and water in ephemeral stream courses (see figures VII-6 and VII-7). A variety of unusual cavities and swallow nests along the rock walls below the protruding ledges associated with the

LEGEND

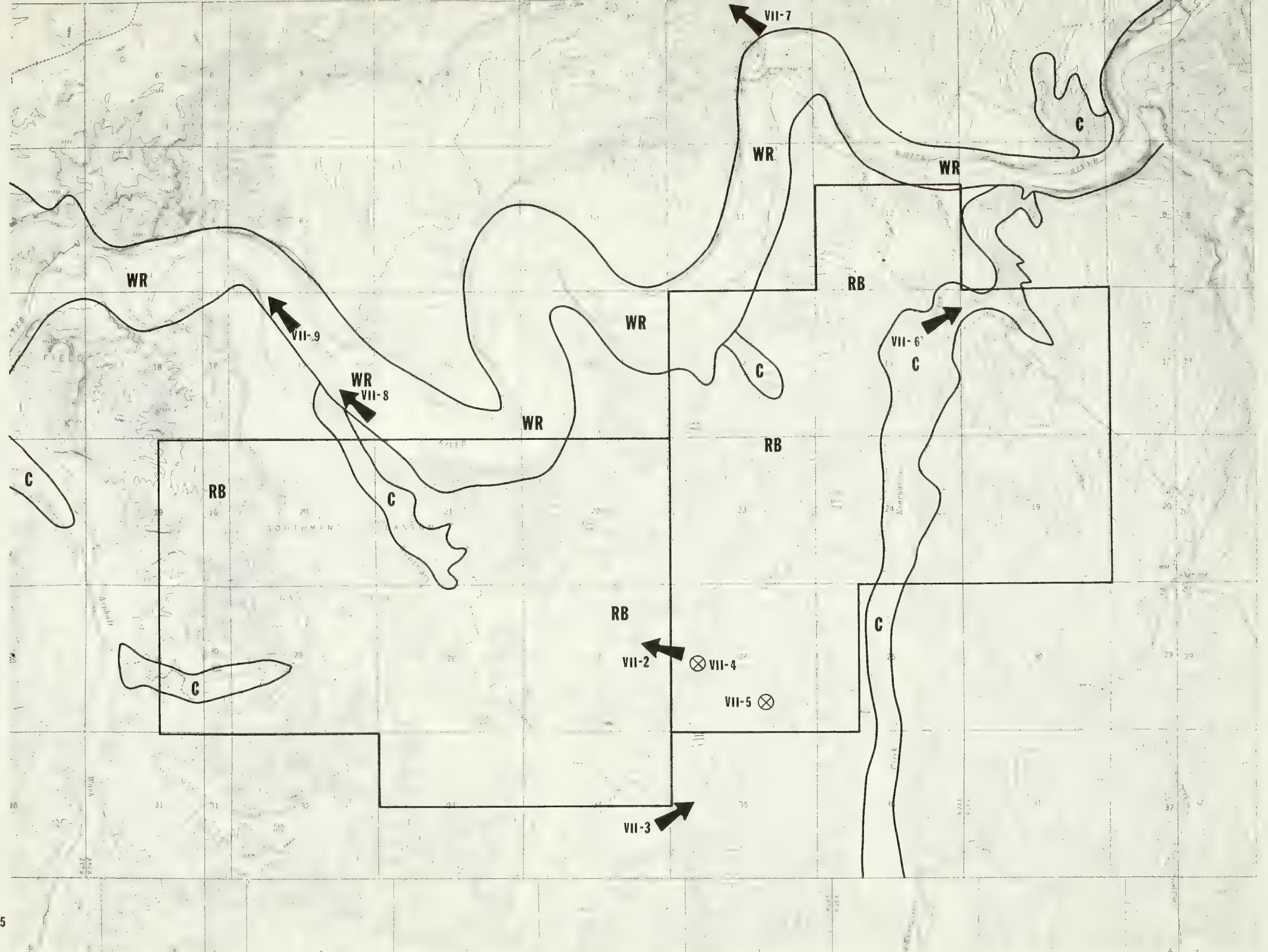
LANDSCAPE UNITS

WR - WHITE RIVER
C - CANYON
RB - RIDGETOP-BASIN COMPLEX

PHOTOGRAPH ORIENTATION

➔ DIRECTION OF PHOTO WITH FIGURE NUMBER

⊗ PHOTO DIRECTION IS VERTICALLY DOWNWARD



LANDSCAPE UNITS & PHOTOGRAPH ORIENTATIONS FOR EVALUATING AESTHETIC RESOURCES

VII-3

FIGURE VII-1

FIGURE VII-2
(PLUS-X, 1/250, F. 11, F.L. inf.)
SOUTHAM CANYON



FIGURE VII-3
(PLUS-X, 1/500, F. 16, F.L. inf.)
RIDGETOP VEGETATION



THESE ARE PANORAMIC VIEWS CHARACTERISTIC OF THE RIDGETOP-BASIN LANDSCAPE UNIT. THE TOP PHOTO WAS TAKEN ON THE RIDGE OVERLOOKING SOUTHAM CANYON, WHILE THE LOWER PHOTO DEMONSTRATES THE SPARSENESS OF VEGETATION, A FACTOR THAT GIVES GREATER EMPHASIS TO GEOLOGIC FEATURES. REFER TO FIGURE VII-1 FOR EXACT LOCATION OF PHOTOGRAPHER POSITION AND DIRECTION OF AIM FOR ALL PHOTOS.

FIGURE VII-4
(PLUS-X, 1/125, F.6, F.L. 3m.)
PINYON TREE



FIGURE VII-5
(PLUS-X, 1/125, F. 8, F.L. 3m.)
WATERPOCKETS



THESE PHOTOS ILLUSTRATE THE UNIQUE DETAIL PREVALENT ON RIDGETOPS AND SUPPLEMENTING THE PANORAMIC VIEWS. THE TOP PHOTO IS A PINYON TREE SPLIT BY LIGHTNING, AND THE BOTTOM PHOTO IS AN EXAMPLE OF THE WATERPOCKETS THAT ADD WATER, A RARE ELEMENT OF THE LANDSCAPE.

FIGURE VII-6
(PLUS-X, 1/125, F. 11.5, F.L. inf.)
EVACUATION CREEK



FIGURE VII-7
(PLUS-X, 1/125, F. 14, F.L. inf.)
CANYON WALL CAVITIES



THESE TWO ENCLOSED VIEWS ARE CHARACTERISTIC OF THE CANYON LAND-
SCAPE UNIT. THE TOP PHOTO IS LOOKING EAST, FACING DOWNSTREAM ON
EVACUATION CREEK, AND THE LOWER PHOTO, TAKEN ALONG THE ACCESS ROAD
ENTERING TRACT U-a, IS AN EXAMPLE OF THE NUMEROUS CAVITIES FOUND
ON CANYON WALLS.

Green River Formation give Evacuation Creek canyon a coarse, honeycombed appearance. The bird's nest aquifer outcrops here, and many birds have built nests in the cavities. Soaring birds are occasionally seen gliding with the mid-morning convective wind currents far above the canyon walls.

The nearly vertical walls focus attention in the canyon and along the sharp boundary between the walls and the usually clear Utah sky. The canyons wind with the stream channel.

A distinctive white bed of volcanic ash with a sandstone texture is visible along the walls of Evacuation Creek. Quicksand is encountered in the creekbed where the bird's nest aquifer discharges water into the stream's sandy alluvium. Bubbles of relatively clear ground water boil up through the sand or along the edge of the creekbed and form pools, in extreme contrast to the turbid stormflow subsequent to summer thunderstorms and spring runoff. Desert varnish, composed of the reds, blues, and blacks of oxides of iron and manganese, gives a tapestried appearance to canyon walls and overhanging ledges. Mudflows have also streaked the walls.

In contrast to Southam Canyon, Asphalt Wash, and tributaries to the White River, Evacuation Creek has more confined views, more frequent streamflow, and more vegetation types, including the more colorful riparian associations. Southam Canyon has fewer enclosed views, and Asphalt Wash has fewer meanders and is in a more symmetrical valley.

c. The White River Landscape Unit

Since the White River is the most prominent feature and the only perennial stream on Tracts U-a and U-b within a 1.6-km (1-mi) radius, it is considered here as a separate landscape unit. Although the views are characteristically enclosed within canyon walls, considerable detail and movement can be observed from the river itself (see figures VII-8 and VII-9). The canyon walls are steep and in places are composed of stream-cut facets with large vertical relief and vertical joint and fracture lines superimposed on the horizontal bedding stratifications. The land-water interface along the river is a continuation of point bars protruding from the canyon walls and cut banks on the opposite side of the river. Thinly laminated silt beds on the bars and alluvial deposits of various sizes are exposed on the cut banks as a cross section of the river's history. Rock ledges, rock windows, rock alcoves, and recent rockfalls are common. The highest ridge visible from the river is in sharp, jagged contrast with the sky.

FIGURE VII-8
(PLUS-X, 1/250, F.16, F.L.inf.)
WHITE RIVER



FIGURE VII-9
(PLUS-X, 1/250, F.16, F.L.inf.)
WHITE RIVER VEGETATION



THESE TWO VIEWS ARE COMMON IN THE WHITE RIVER LANDSCAPE UNIT, ILLUSTRATING THE ARRAY OF FLUVIAL LANDFORMS AND CONTRAST IN VEGETATION TYPES.

Channel bars, snags, and driftwood are common in the river. Beaver caches and their builders are sometimes seen. Lower point bars show evidence of meander scars, which emphasize the sinusoidal nature of the channel pattern. The more stable point bars are thickly vegetated with green cottonwoods. Cattle frequently occupy these riparian areas, and deer are occasionally seen, particularly east of Ignacio Bridge.

Numerous insects, lizards, and snakes appear frequently along the stream banks to attract the observer's attention. Ducks, Canada geese, various shorebirds, and soaring raptors add to the aesthetic setting. Dilapidated cabins once belonging to shepherds are visible from the river 3 km (2 mi) downstream at Ignacio Bridge. An abandoned oil shale mine and trestle are visible between the turbid, reflections of sunlight can often be seen from the bridge or from the riffles at sunrise. At sunset, long shadows on the river emphasize ridgeform and vegetation shapes.

Two seasonal aspects of the aesthetic setting are especially evident along the White River. In winter the river freezes and forms a white band of ice that winds through the canyon. In fall some of the riparian vegetation turns red, orange, and yellow and contrasts with evergreen shrubs and trees.

C. INTERPRETATION AND CONCLUSIONS

The Uinta Basin and Tracts U-a and U-b are characterized by a variety of aesthetic resources. The landforms surrounding the basin--the Uinta Mountains, the Book Cliffs, the Wasatch Plateau, and the Green River--are the dominant and most accessible features. Although the tracts are a harsh, arid environment subject to climatic extremes, they nevertheless contain an abundance of unusual and interesting aesthetic features. Elevated landforms and clear air afford spectacular panoramic views with no human influence. The many unique geologic formations set against the clear Utah sky include rock windows, balanced rocks, odd rock shapes, monoliths, and multi-patterned canyon walls. Closer inspection of many of these formations reveals micro-landforms and patterns. The White River and its lush riparian areas are a contrast to the sparsely-vegetated desert.

The tracts were divided into three distinct landscape units --the ridgetop-basin complex, the canyons, and the White River. The most pleasing feature of the ridgetop-basin unit is the spectacular panoramic views of the surrounding landscape and the unique geologic features that can be seen from the ridgetops. The ridgetops themselves are characterized by unusual micro-landforms.

The canyon areas include Evacuation Creek, lower Southam Canyon, Asphalt Wash, and all steep-walled tributaries to these drainages and to the White River. The landscape is characterized by vegetation, water in ephemeral streams, and unusual geologic detail, such as the protruding ledges of the Green River Formation and the nahcolite formations of the bird's nest aquifer outcrops.

The White River, the only perennial stream on the tracts, is enclosed within canyon walls. The thick vegetation and cottonwood trees along the river are often occupied by cattle. These riparian areas are a pleasing contrast to the sparse vegetation and stark geological detail of the surrounding area.

In summary, no one landscape unit as described can be designated more aesthetically sensitive than the other. The oil shale tracts and the region surrounding them are diverse and unique, and any areas proposed for commercial development (i.e., retort site, spent shale disposal site, roads, power lines, etc.) should be judged individually and collectively to fully evaluate the potential aesthetic impacts.

D. EVALUATION OF BASELINE PROGRAM

The aesthetic resources study was conducted to comply with lease stipulations requiring that scenic and aesthetic values be considered in the plan and design of all construction, mining, and reclamation operations. Existing conditions were documented by photograph prior to initiation of any data collection and monitoring activities so that any unique visual features would be protected.

The baseline information from the study has been, and will continue to be, incorporated into the facilities design to minimize visual impacts, make use of the natural topography, and achieve harmony with the landscape.



VIII

REVEGETATION PROGRAM

VIII. REVEGETATION PROGRAM

The purpose of the revegetation program was to reseed areas disturbed by the exploration and environmental activities conducted during the baseline study.

Revegetation efforts for the processed shale disposal areas are being conducted by the Agricultural Experiment Station of Utah State University (USU). Greenhouse studies are continuing at USU, Logan, Utah, and field revegetation studies using processed shale are being conducted north of Tract U-b. The results of these investigations have been, and continue to be, reported in separate documents and are on file at the AOSS in Grand Junction, Colorado.

Reseeding of disturbed areas on Tracts U-a and U-b has been completed. Drill sites and access to drill sites were reseeded in fall 1975 using the following procedures, which were approved by the Area Oil Shale Office (AOSS) and the Bureau of Land Management (BLM).

Site G-17 (On Tract)

Spread straw, mulched in (approximately 6"), broadcast seed and disked lightly, used 4 bales of straw (Rate 1 Ton/AC).

Seed used:	Indian Rice Grass	$\frac{1}{4}$ lb.
	Pubescent Wheatgrass	$\frac{1}{4}$ lb.
	Bottlebrush Squirrel Tail	$\frac{1}{4}$ lb.
	Alkali Sacaton	$\frac{1}{4}$ lb.
	Douglas Rabbitbrush	$\frac{1}{4}$ lb.
	Rubber Rabbitbrush	$\frac{1}{4}$ lb.
	Black Sagebrush	$\frac{1}{4}$ lb.
	Big Sagebrush	$\frac{1}{4}$ lb.

Site P-1 (On Tract)

Ripped on contour, spread straw, mulched in straw 4" to 6", broadcast seed, disked lightly, used 86 bales of straw (Rate 2 Ton/AC).

Seed used:	Fairway Wheatgrass	4 lbs.
	Russian Rye	4 lbs.
	Yellow Wheat Clover	4 lbs.
	Squirrel Tail	3 lbs.
	Indian Rice Grass	4 lbs.
	Douglas Rabbitbrush	3 lbs.
	Rubber Rabbitbrush	3 lbs.
	Black Sagebrush	3 lbs.
	Big Sagebrush	3 lbs.

Site X-5 (On Tract)

Spread straw, mulched in (approximately 6"), broadcast seed, harrowed lightly, used 14 bales of straw (Rate 2 Ton/AC), disked road.

Seed used:	Indian Rice Grass	$\frac{1}{2}$ lb.
	Pubescent Wheatgrass	$\frac{1}{2}$ lb.
	Bottlebrush Squirrel Tail	$\frac{1}{2}$ lb.
	Alkali Sacaton	$\frac{1}{2}$ lb.
	Douglas Rabbitbrush	$\frac{1}{2}$ lb.
	Black Sagebrush	$\frac{1}{2}$ lb.
	Big Sagebrush	$\frac{1}{2}$ lb.
	Rubber Rabbitbrush	$\frac{1}{2}$ lb.

Site X-4 (On Tract)

Spread straw, mulched in (approximately 6"), broadcast seed, harrowed lightly, used 16 bales of straw (Rate 2 Ton/AC), disked around old well head.

Seed used:	Fairway Wheatgrass	$\frac{1}{2}$ lb.
	Russian Rye	$\frac{1}{2}$ lb.
	Yellow Wheat Clover	$\frac{1}{4}$ lb.
	Squirrel Tail	$\frac{1}{4}$ lb.
	Indian Rice Grass	$\frac{1}{4}$ lb.
	Douglas Rabbitbrush	$\frac{1}{4}$ lb.
	Rubber Rabbitbrush	$\frac{1}{4}$ lb.
	Black Sagebrush	$\frac{1}{4}$ lb.
	Big Sagebrush	$\frac{1}{4}$ lb.

Site G-5 (On Tract)

Spread straw, mulched in (approximately 6"), broadcast seed, harrowed and used 6 bales of straw (Rate 1 Ton/AC).

Seed used:	Indian Rice Grass	$\frac{1}{4}$ lb.
	Pubescent Wheatgrass	$\frac{1}{4}$ lb.
	Bottlebrush Squirrel Tail	$\frac{1}{4}$ lb.
	Alkali Sacaton	$\frac{1}{4}$ lb.
	Douglas Rabbitbrush	$\frac{1}{4}$ lb.
	Black Sagebrush	$\frac{1}{4}$ lb.
	Big Sagebrush	$\frac{1}{4}$ lb.
	Rubber Rabbitbrush	$\frac{1}{4}$ lb.

Site G-7 and P-3 (Off Tract)

Spread straw, lightly mulched in (approximately 2"), drilled seed in, disked up roadway. Ralph Heft (BLM representative)

instructed us to not mulch in straw as deep as we have on the above locations. All locations after October 31, 1975, were not mulched as specified. Used 128 bales of straw (Rate 1 Ton/AC).

Seed used:	Indian Rice Grass	3 lbs.
	Pubescent Wheatgrass	3 lbs.
	Bottlebrush Squirrel Tail	1½ lbs.
	Alkali Sacaton	1½ lbs.
	Douglas Rabbitbrush	1½ lbs.
	Black Sagebrush	1½ lbs.
	Big Sagebrush	1½ lbs.
	Rubber Rabbitbrush	1½ lbs.

Site G-4 and G-15 (On Tract)

Spread straw, lightly mulched (2" to 3"), drilled seed, disk up road, used 40 bales of straw (Rate 1 Ton/AC).

Seed used:	Fairway Wheatgrass	½ lb.
	Russian Rye	½ lb.
	Yellow Wheat Clover	¼ lb.
	Squirrel Tail	¼ lb.
	Indian Ricegrass	¼ lb.
	Douglas Rabbitbrush	¼ lb.
	Rubber Rabbitbrush	¼ lb.
	Black Sagebrush	¼ lb.
	Big Sagebrush	¼ lb.

Site X-10 (On Tract)

Spread straw, lightly mulched (approximately 3"), broadcast seed, lightly disked over seed, used 24 bales of straw (Rate 1 Ton/AC), also 1 lb. four-Wing Saltbrush.

Seed used:	Indian Rice Grass	½ lb.
	Pubescent Wheatgrass	½ lb.
	Bottlebrush Squirrel Tail	½ lb.
	Alkali Sacaton	½ lb.
	Douglas Rabbitbrush	½ lb.
	Black Sagebrush	½ lb.
	Big Sagebrush	½ lb.
	Rubber Rabbitbrush	½ lb.
	Four-Wing Saltbrush	1 lb.

Site X-9 (On Tract)

Spread straw, lightly mulched in (approximately 3"), broadcast seed, lightly disked over seed, disked last portion of road to stop traffic, used 28 bales of straw (Rate 1 Ton/AC).

Seed used:	Indian Rice Grass	2 lbs.
	Pubescent Wheatgrass	2 lbs.
	Bottlebrush Squirrel Tail	2 lbs.
	Alkali Sacaton	2 lbs.
	Douglas Rabbitbrush	2 lbs.
	Black Sagebrush	2 lbs.
	Big Sagebrush	2 lbs.
	Rubber Rabbitbrush	2 lbs.

Site G-1 (On Tract)

Ripped location, spread straw, lightly mulched, broadcast seed, broadcast nitrogen fertilizer (15 lbs.), used 12 bales of straw (Rate $1\frac{1}{2}$ Ton/AC). For east half of location between road and well.

Ripped location, applied 525 lbs. of sawdust and 15 lbs. nitrogen, drilled seed and rolled location. For west half of location.

Seed used:	Fairway Wheatgrass	$\frac{1}{2}$ lb.
	Russian Rye	$\frac{1}{2}$ lb.
	Yellow Wheat Clover	$\frac{1}{4}$ lb.
	Squirrel Tail	$\frac{1}{4}$ lb.
	Indian Rice Grass	$\frac{1}{4}$ lb.
	Douglas Rabbitbrush	$\frac{1}{4}$ lb.
	Rubber Rabbitbrush	$\frac{1}{4}$ lb.
	Black Sagebrush	$\frac{1}{4}$ lb.
	Big Sagebrush	$\frac{1}{4}$ lb.

Fertilizer used was Nitrogen 21% in Ammonia form
Sulphur 24% (Combined)

Site P-2 (On Tract)

Ripped location, spread straw, lightly mulched, broadcast seed, disked lightly, used 66 bales of straw (Rate 2 Ton/AC).

Seed used:	Indian Rice Grass	$2\frac{1}{2}$ lbs.
	Pubescent Wheatgrass	$2\frac{1}{2}$ lbs.
	Bottlebrush Squirrel Tail	$2\frac{1}{2}$ lbs.
	Alkali Sacaton	$2\frac{1}{2}$ lbs.
	Douglas Rabbitbrush	$2\frac{1}{2}$ lbs.
	Black Sagebrush	$2\frac{1}{2}$ lbs.
	Big Sagebrush	$2\frac{1}{2}$ lbs.
	Rubber Rabbitbrush	$2\frac{1}{2}$ lbs.

Site G-8 (On Tract)

Ripped location, spread straw, lightly disked in, broadcast seed and lightly disked, used 14 bales of straw (Rate 2 Ton/AC).

Seed used:	Fairway Wheatgrass	1½ lbs.
	Russian Rye	2 lbs.
	Yellow Wheat Clover	1 lb.
	Squirrel Tail	½ lb.
	Indian Rice Grass	½ lb.
	Douglas Rabbitbrush	½ lb.
	Rubber Rabbitbrush	½ lb.
	Black Sagebrush	½ lb.
	Big Sagebrush	½ lb.

Site X-3 (On Tract)

Spread straw, disked lightly, broadcast seed, disked lightly, used 16 bales of straw (Rate 1 Ton/AC).

Seed used:	Fairway Wheatgrass	½ lb.
	Russian Rye	½ lb.
	Yellow Wheat Clover	½ lb.
	Squirrel Tail	½ lb.
	Indian Rice Grass	½ lb.
	Douglas Rabbitbrush	½ lb.
	Rubber Rabbitbrush	½ lb.
	Black Sagebrush	½ lb.
	Big Sagebrush	½ lb.

Note: This location has a lot of shale rock on the surface of the ground.

Site G-6 and G-19 (Off Tract-BLM)

Ripped location, disked, broadcast seed, disked lightly and spread Juniper and Sagebrush mulch and set nine Rabbitbrush and 2 four-Wing Saltbrush bushes on location.

Seed used:	Fairway Wheatgrass	2¼ lbs.
	Russian Rye Grass	3 lbs.
	Yellow Wheat Clover	1½ lbs.
	Squirrel Tail	¾ lb.
	Indian Rice Grass	¾ lb.
	Douglas Rabbitbrush	¾ lb.
	Rubber Rabbitbrush	¾ lb.
	Black Sagebrush	¾ lb.
	Big Sagebrush	¾ lb.

Following reseedling, the sites were inspected by agency personnel (AOSO and BLM), who determined that the reseedling was well done and that the sites were left in good condition. The following are selected photographs of some of the sites visited during this inspection (see figures VIII-1 through VIII-5).

The conditions for reseedling success were excellent during spring 1975; however, in spring 1976 conditions were poor for the new seedlings as well as for the existing vegetation. Perhaps in only two out of five years will conditions be favorable for any significant regeneration success. The success of the fall 1975 seeding program can be evaluated only by observing at least two growing seasons (spring 1976 and spring 1977) and possibly a third season (spring 1978).



FIGURE VIII-1

G-6 AND G-19

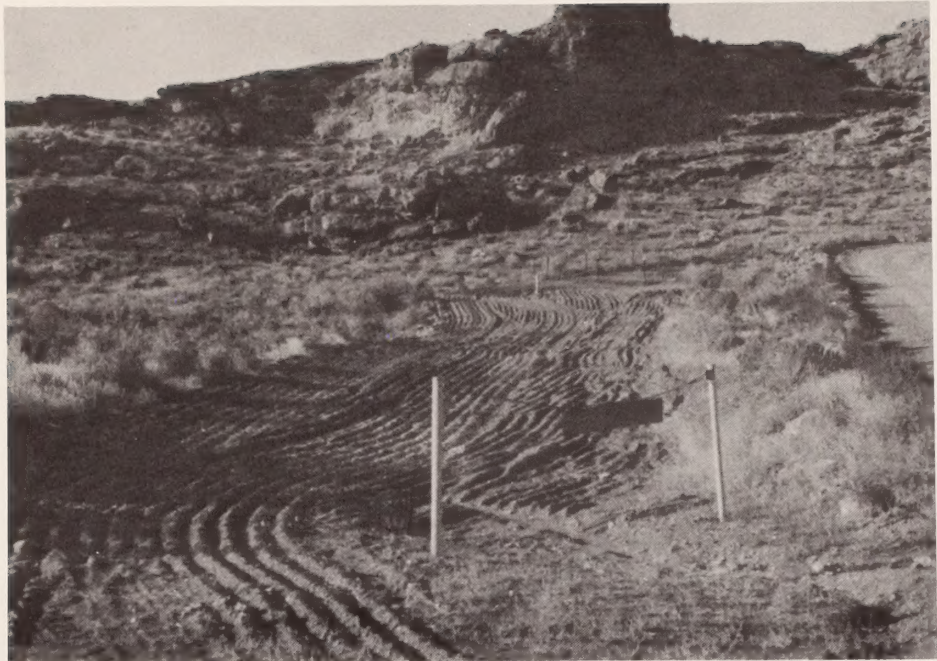


FIGURE VIII-2
RESEEDED DRILL SITE G-17



FIGURE VIII-3
P-1



FIGURE VIII-4

X-5



FIGURE VIII-5

G-7 AND P-3

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BORROWER'S

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Final environmental
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